Australian Physics

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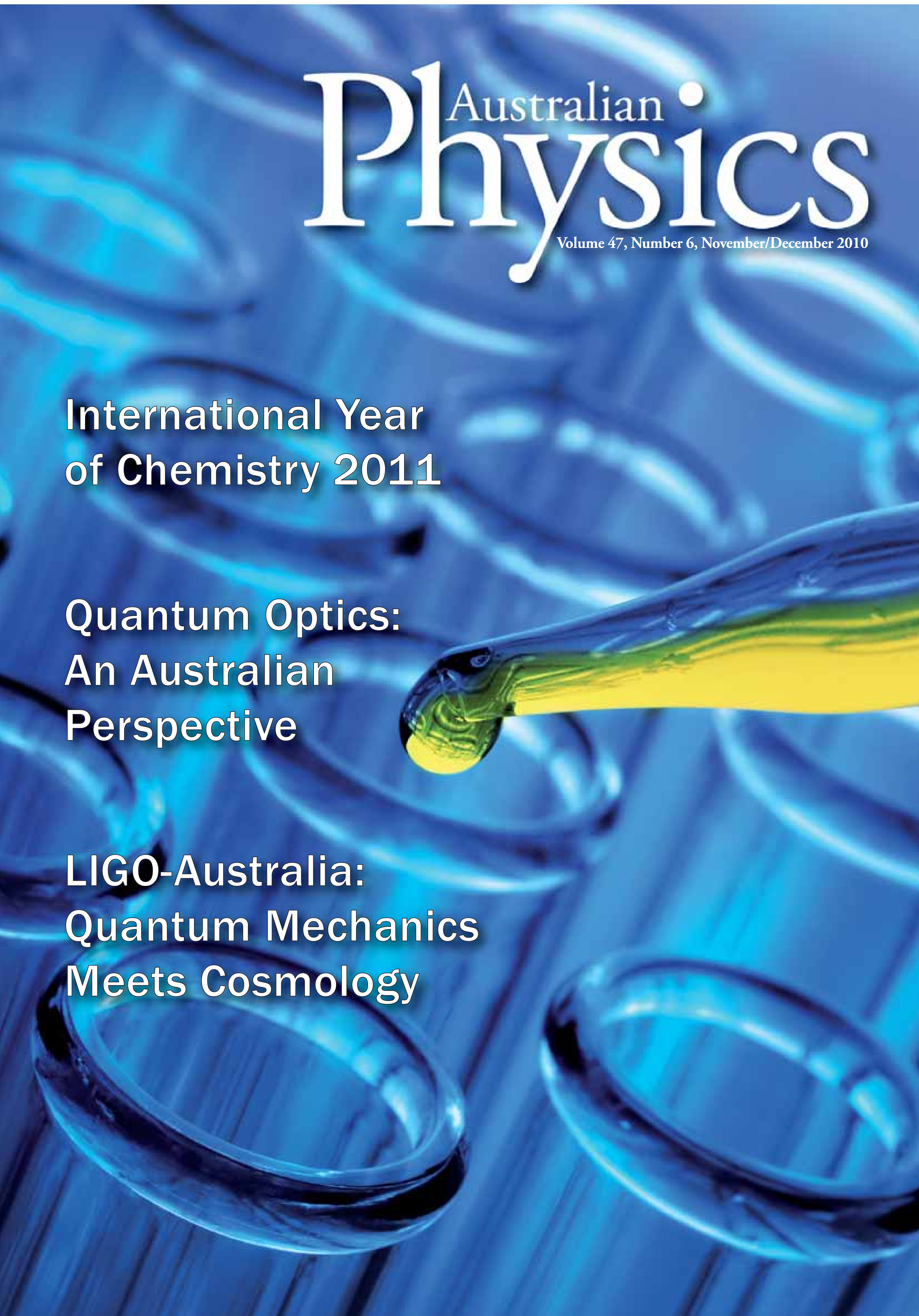

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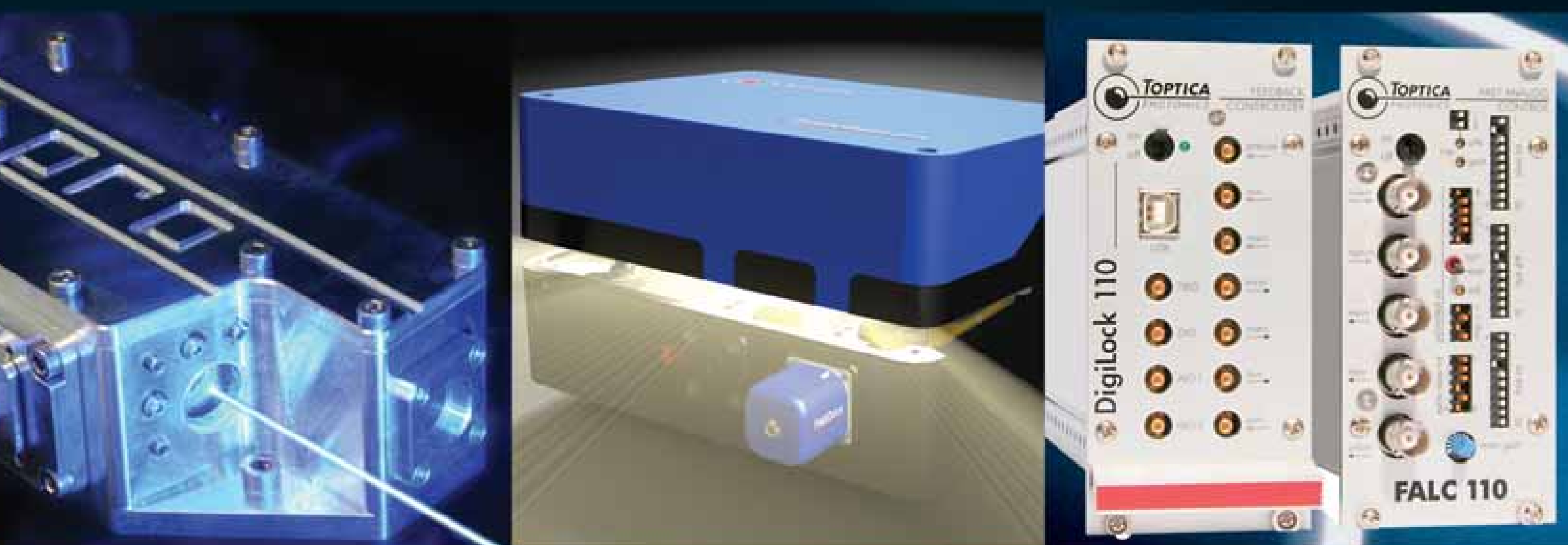

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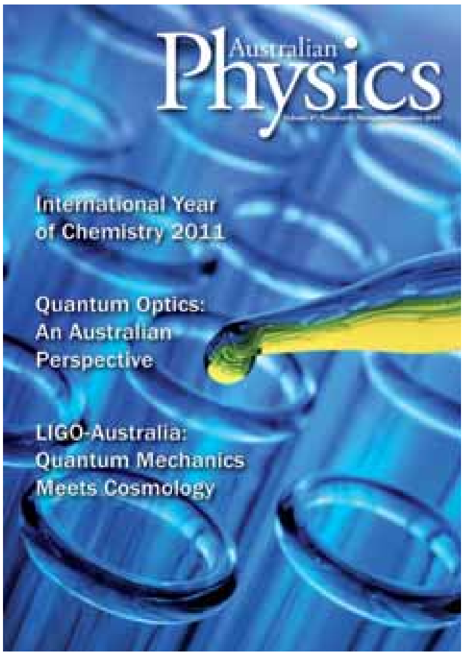

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Submission Guidelines

Articles for submission to *Australian Physics* should be sent in electronicaly. Word or rich text format are preferred. Images should not be embedded in the document, but should be sent as high resolution attachments in eps, tiff or jpg format. Authors should also send a short bio and a recent photo. The Editor reserves the right to edit articles based on space requirements and editorial content. Contributions should be sent to the Editor.

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Editorial

International Year of Chemistry

In terms of international recognition and celebration, the sciences have fared relatively well in recent years. In 2005 it was our turn as we celebrated the centenary of Albert Einstein's *annus mirabilis*. The series of papers he published in 1905 helped lay the foundations for the two great triumphs of twentieth-century physics – general relativity and quantum mechanics.

In 2009 we celebrated the International Year of Astronomy, marking 400 years since Galileo trained the first telescope to the skies and discovered, among others, the moons of Jupiter. Last year was the International Year of Biodiversity, though this was no celebration as we learnt of the tragic and accelerating decline in the world's biodiversity.

This year it is the turn of the chemists, who are celebrating the centenary of the award of the Nobel Prize for Chemistry to Marie Curie in 1911. Curie was not only the first woman to win a Nobel Prize, but she was also the first of a rare group of scientists to have won two. Physicists, as much as chemists, can in fact claim Curie to be one of their own. In 1903 she was awarded the Nobel Prize for Physics, along with husband Pierre Curie and Henri Becquerel, 'in recognition of the extraordinary services they have rendered by their joint researches on the radiation phenomena discovered by Professor Henri Becquerel'.

In this issue Katrina Beikoff describes some of the activities and events planned to celebrate the International Year of Chemistry in Australia. We also have an article by Hans Bachor on the development of quantum optics in Australia, based on the lecture he gave on receiving the Harrie Massey Medal for 2010.

Lastly, Jesper Munch and colleagues present a compelling case as to why Australia should host a next-generation Laser Interferometer Gravitational Observatory (LIGO) to complement the three currently under development in the Northern Hemisphere – two in the United States and one in Italy.

Over the next few issues I plan to introduce others in the editorial and production team for *Australian Physics*. It is a pleasure to welcome part-time Assistant Editor, Dr Akin Budi.

Akin Budi is a Research Fellow in Physics at The University of Melbourne, where he is currently working on materials for building quantum devices. He specialises in materials modelling using empirical and *ab initio* techniques. He completed his PhD in 2006 at RMIT University where he investigated the effects of external stresses on proteins. In his postdoctoral position, he was part of a team working on hydrogen storage materials. Akin then completed a project with CSIRO Energy Technology to study the formation of solid–liquid interphase on the next generation battery technology.

President's column

Peer Review

As you will no doubt be aware our new editor is pushing out the issues after a period of very slow production of *Australian Physics*. This was foreshadowed but it has meant that he now pesters me for my President's column with barely any breathing space since the last one. That is a good thing though. It keeps me on my toes and thinking.

Before starting my column I would like to congratulate Nanda Dasgupta and Ross McPhedran on their election to the Academy of Science. I would also like to congratulate our Past President, Cathy Foley, on her appointment as Chief of the CSIRO Division of Materials Science and Engineering. This is the largest CSIRO division and the appointment recognises Cathy's outstanding abilities. It is always a delight to see members of our community recognised.

I had been considering for some time the issue of peer review. It is a pillar underlying our way of reporting and funding research and it is the best system we have come up with. In my opinion it surpasses the various publication metrics but has the disadvantage of being much more time consuming and hard work for both the reviewers and the assessors. It certainly helps even out the vagaries of different fields (and the biases that the sizes of those fields create). However, it is by no means a perfect system and there are ways that it could be improved. It is probably a little more robust where funding, awards or appointments are concerned where a panel of experts is involved, rather than in the published literature where it may fall to a single referee to make the call.

It has been clear to me for a long time that a major difficulty in peer review by individual reviewers is consistency; consistency between reviewers and also between fields and disciplines. This comes about because of different backgrounds, skill sets and abilities of reviewers and also because the same words can have different emphasis for different readers. Few, if any, of us are exposed to formal training in refereeing and it is eye opening indeed to sit on the other side in an expert panel and see how much variability the interpretation of many reviews can produce. A really skilled reviewer avoids these uncertainties but all too few consistently achieve this level of clarity and it is even harder when the reviewer's first language is not the same as the members of the assessment panel.

I believe that we have some way to go in improving the individual referee report standard which will have to include formal training. This will continue to impact on publication assessment where one or two referee reports and an editor (who may have limited knowledge of the detailed subject matter) are the sum total of the assessment. However, there has been a steady improvement over the years in the grant/funding/appointment processes assessed by expert panels that redress much of the problem from fairness and openness to equity and impartiality. I was pleased to see the recent publication by the European Science Foundation of its Peer Review Guide. If you want to get a copy you can download it from www.esf.org/publications.html. (Note there are a lot of other very interesting publications from the ESF on this site as well.) This 88-page guide aims to produce a high quality, even, open and fair review system that is common to all of Europe. It was produced through consultation among 23 countries in Europe. The process is based around five 'pillars' of good practice in peer review: Core Principles, Governance Structures, Quality Assurance, Process Integrity, and Methodology. Within the Core Principles are: Excellence, Impartiality, Transparency, Appropriateness for Purpose, Efficiency and Speed, Confidentiality, and Ethical and Integrity Considerations. All funding bodies would aim to meet a similar set of rules of good practice. There is a lot in the report including useful references to other reports on peer review and it is probably worth a scan for many and a deeper read for people who are responsible for structures that use peer review heavily. It is clear that a right of reply is fundamental to their thinking, something that has sometimes not been given the level of importance it deserved.

In the publication domain a more open review system is emerging. It is the prepublication by the journal of a paper together

with initial reviews and author responses with a structure for open discussion of the paper contents. This can be either open to journal subscribers only or be completely open source. The discussion then allows improvements to the paper but also adds value to the whole process. This is a new way of publishing that possibly needs some further development but is something that I find quite appealing. I do wonder how we are going to deal with the added value from the correspondents though. They deserve some recognition for the effort they put in, just as they get now for being referees. But that is an issue for further down the track. At least it is good to see that reviewing systems are not remaining static, but are developing along with the technology we are using to deliver knowledge.

It has been clear to me for a long time that a major difficulty in peer review by individual reviewers is consistency; consistency between reviewers and also between fields and disciplines.


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Two physicists elected Fellows of the AAS

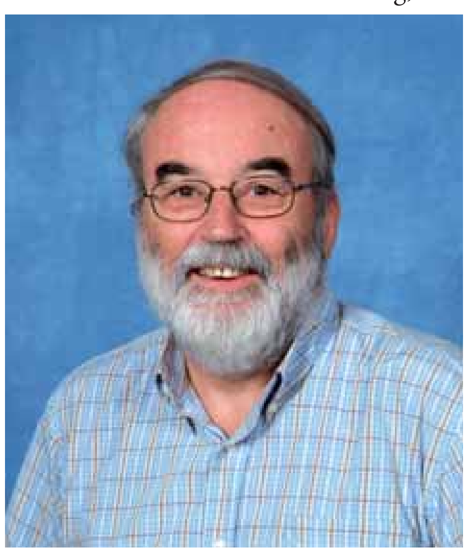
Seventeen of Australia's leading scientists were honoured on in March 2011 by election to the Australian Academy of Science. New members include two physicists, Professor Mahananda Dasgupta (Australian National University) and Professor Ross McPhedran (University of Sydney), both members of the AIP.

Mahananda (Nanda) Dasgupta obtained her PhD from the Tata Institute of Fundamental Research in Mumbai, India, in 1992. She then joined the Department of Nuclear Physics at the Australian National University, where she gained an international reputation for her work on the effects of quantum coherence in fusion of heavy nuclei. Measurements of unmatched precision were made at the Heavy Ion Accelerator Facility at the ANU, demonstrating that a 'distribution of barrier energies' rather than a single fusion (Coulomb) barrier is encountered in nuclear collisions – a discovery that was recognised in the US long range plan for nuclear physics as 'a breakthrough that will have continuing significance'.

In 1998 Nanda was awarded a Queen Elizabeth II Fellowship to pursue her research in nuclear reaction dynamics. Developing innovative experimental techniques and instrumentation to make measurements of quantum tunnelling with unprecedented sensitivity, as well as driving theoretical collaborations, her group made major advances that changed the way we understand the quantum dynamics of fundamental fusion and fission processes. The group is currently interested in understanding irreversibility and loss of coherence in nuclear collisions – sharing features with other quantum systems, yet unique in being completely isolated from any external environment.

Nanda's work has been recognised by her selection as the 2004 Women in Physics Lecturer by the Australian Institute of Physics, and by the award of the Pawsey Medal by the Australian Academy of Science in 2006.

Ross McPhedran is a Chief Investigator in the Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), an ARC Centre of Excellence, and holds a Personal Chair in Electromagnetic Physics at the University of Sydney. His research interests lie in the broad field of wave science, and in particular in the interaction of electromagnetic and elastic waves with structured materials. He has been a pioneer in the development of multipole methods for the calculation of the properties of composite materials for applications such as solar collectors, and for the study of photonic crystals and photonic crystal fibres. These are being developed for new applications in communication science and sensing, and



were at the core of the initial research program of CUDOS. He is also an internationally recognised leader in the new fields of plasmonic nanostructures and metamaterials.

Ross did his undergraduate and postgraduate studies at the University of Tasmania, where he completed a PhD under the supervision of Dr Michael Waterworth. Ross has been at the University of Sydney since 1975, apart from periods of study leave taken at Caltech, the University of Bath and the Universite Paul Cezanne in Marseille. He has over 270 reviewed scientific publications, which have attracted over 6000 citations. He has served on the editorial boards of the international journals *Optics Communications*, *Journal of Modern Optics*, *Proceedings of the Royal Society A* and *Waves in Random and Complex Media*.

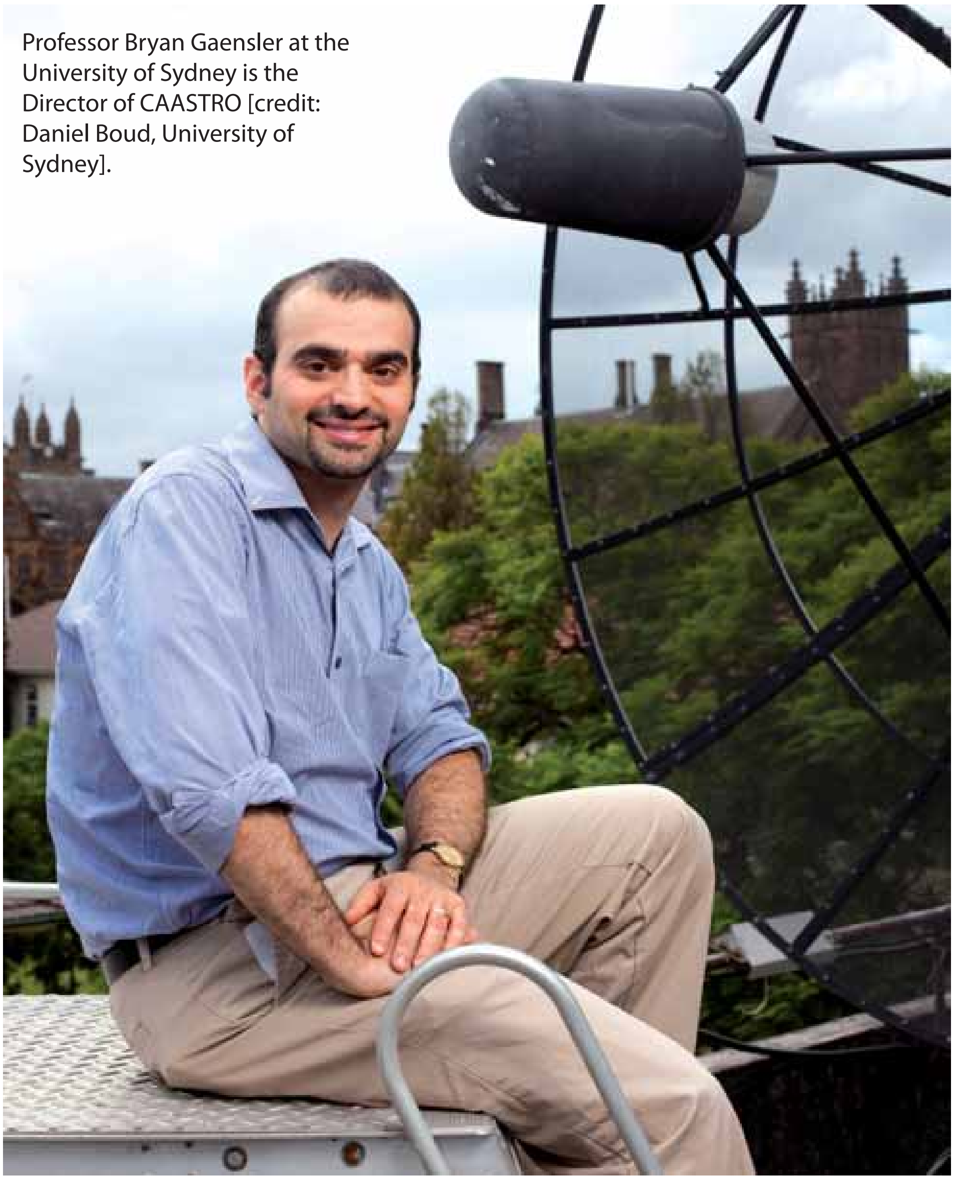
Ross is a Fellow of the Australian Institute of Physics, the Institute of Physics (UK) and the Optical Society of America. He was awarded the Australian Optical Society Medal in 2004, and a Doctorate Honoris Causa by the Universite Paul Cezanne in 2010.

CAASTRO up and running

Australian astronomers have launched a major new initiative, in the form of the ARC Centre of Excellence for All-sky Astrophysics – or 'CAASTRO'. The new Centre aims to be the international leader in wide-field astronomy, positioning Australia to address fundamental unsolved questions about the Universe with the dramatic capabilities of next-generation telescopes and advanced instrumentation. CAASTRO is receiving $20.6 million in ARC funding over the period 2011-2018 to pursue these goals, together with a further $7.5 million from the participating organisations.

CAASTRO is led by the University of Sydney with Professor Bryan Gaensler as Director, in conjunction with the Australian National University, the University of Melbourne, the University of Western Australia, Curtin University and Swinburne University, complemented by a group of Australian partners and international organisations in Europe, Canada and the United States.

There is a growing realisation that the outstanding unsolved questions in astronomy demand entirely new approaches, requiring enormous data sets covering thousands of square degrees of sky. In the last few years, Australia has invested more than $400 million both in new wide-field telescopes and in the high-performance computers needed to process the resulting torrents of data. These developments now present a window of opportunity for Australia to establish itself at the vanguard of the upcoming information revolution centred around all-sky astronomy.



Professor Bryan Gaensler at the University of Sydney is the Director of CAASTRO [credit: Daniel Boud, University of Sydney].

CAASTRO has assembled a world-class team needed to exploit the scientific potential of these exciting new wide-field facilities. The Centre aims to deliver transformational new science by bringing together unique expertise in radio astronomy, optical astronomy, theoretical astrophysics and computation, and by coupling all these capabilities to the powerful technology in which Australia has recently invested.

The CAASTRO team will be pursuing three broad and interlinked scientific programs:

- The Evolving Universe: When did the first galaxies form, and how have they then evolved?
- The Dynamic Universe: What is the high-energy physics that drives change in the Universe?
- The Dark Universe: What are the Dark Energy and Dark Matter that dominate the cosmos?

Twelve research positions were advertised internationally in late 2010, spread across all six CAASTRO nodes and all three research programs. It is anticipated that the official launch of CAASTRO will be held at Sydney Observatory in July this year, subject to the availability of the Federal Minister for Science, Senator Kim Carr.

Back issues of *Aust. J. Phys.* now online

The entire catalogue of the *Australian Journal of Physics* has been made available online by CSIRO Publishing. In 1997 the *Aust. J. Phys.* was the first Australian science journal to go online, followed closely by the other ten journals known collectively as the 'Australian Journals of Scientific Research'. The AJSR are published by CSIRO Publishing under a long-standing agreement between CSIRO and the Australian Academy of Science.

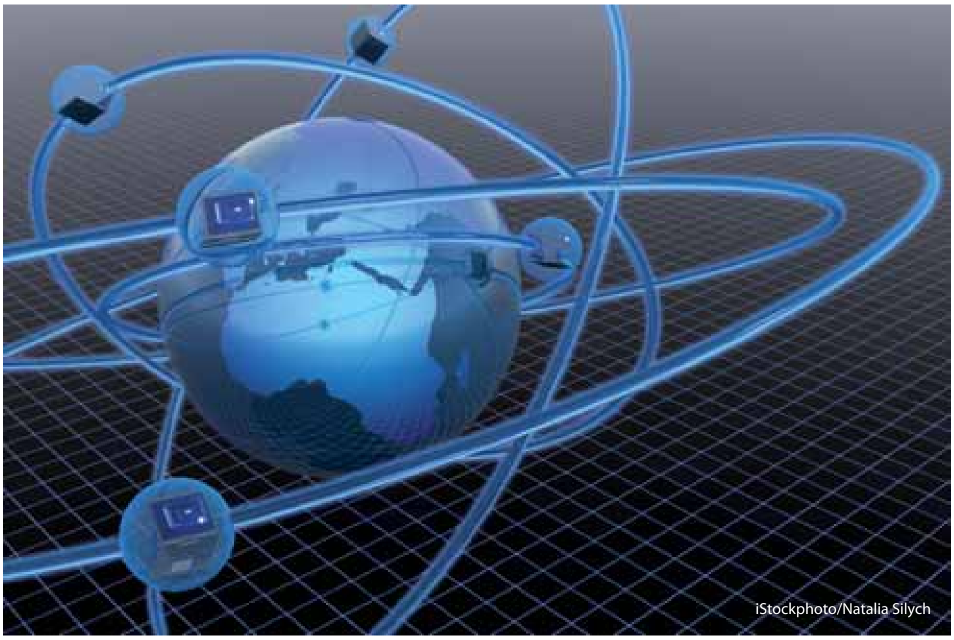
The online version of the *Aust. J. Phys.* was published in parallel with the print version until 2001, when the controversial decision was made to cease publication of the journal. The driving force behind the decision to make back issues available online has been Professor Bob Crompton from the Australian National University. A former chair of the *Aust. J. Phys.* Editorial Board, Crompton has been a long-term and influential advocate for the Australian Journals of Scientific Research.

The process to get back issues online took several months to complete. First a complete run of the journal back to 1953 had to be located, one which could be sacrificed by guillotining the spines and then loading the pages for each issue onto a scanner. After scanning and proofing, a PDF file for each paper in every issue in each annual volume was then uploaded onto the CSIRO Publishing website.

The journal began in 1953 after the original *Australian Journal of Scientific Research, Series A,* begun in 1948, was split into the *Aust. J. Phys.* and the *Australian Journal of Chemistry*. Back issues of the original *AJSR* for 1948-53 have already been made available on the *Aust. J. Chem.* website.

The availability of these back issues will be welcomed by historians of Australian science. As one example, about a half of the research papers produced by the early Australian pioneers of radio astronomy in CSIRO Radiophysics appeared in the *Australian Journal of Scientific Research* and then the *Aust. J. Phys.*

The online version of *Aust. J. Phys.* can be accessed for free and is available from the CSIRO Publishing website at www.publish.csiro.au.



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International Year of Chemistry 2011

Katrina Beikoff

In February an exciting International Year of Chemistry events and activities kicked off around the nation, starting with the grand IYC Australia 2011 National Launch in Canberra

The International Year of Chemistry 2011 (IYC 2011) is garnering great support and interest in Australia and all signs are that it is being embraced not only by the science community, but also by business, schools and academia, and the general public. The year-long IYC 2011 celebrations, spearheaded by the Royal Australian Chemical Institute (RACI), recognise the achievements of chemistry and its contributions to the well-being of humankind.

Events and activities engage the theme 'Chemistry: Our Life, Our Future'. Events around the nation aim to firmly plant chemistry as a focal point in our lives and the world around us. The IYC 2011 is a celebration that chemistry is indeed an extraordinary tool.

Chemistry is fundamental to our understanding of the world and the cosmos. It is chemistry that enables us to understand and manipulate the structure of matter. And it is chemistry that allows us to dissect the molecules of life and understand what makes our planet, and everyone of us, tick. Chemistry is vital for our future and this is why, in Australia and around the world, we are celebrating the art and science of chemistry.

"Chemistry affects all of our lives and our future, so it's certainly the right time for us to get involved in celebrating the IYC 2011"

The year 2011 has been chosen deliberately by IUPAC (the International Union of Pure and Applied Chemistry) and UNESCO (the United Nations Educational, Scientific and Cultural Organization) as it coincides with the 100th anniversary of the Nobel Prize in Chemistry being awarded to Marie Curie and emphasises the contributions of women to science. It also represents the 100th anniversary of the founding of the International Association of Chemical Societies, which underlines the benefits of international scientific collaboration.

The IYC 2011 events throughout Australia celebrate these two anniversaries and endeavour to increase the public's appreciation of chemistry as fundamental in meeting world needs, to encourage interest in chemistry among young people, and to generate enthusiasm for the creative future of chemistry.

Major events being held throughout the country this year include:

- the IYC Australia 2011 National Launch
- a National Tour of Australian and internationally renowned chemists
- the National Chemistry Quiz that will run in countries right around the globe
- National Chemistry Week
- National Science Week
- the RACI National Awards
- travelling exhibitions on the achievements and application of chemistry, a global experiment for students that is expected to become the world's largest ever chemistry experiment by the end of the year
- an artistic interpretation of chemistry's most fundamental tool – the periodic table.

The IYC Australia 2011 launch was held in Canberra on 8 and 9 February 2011. The inspiring launch stakeholders of IYC 2011 activities and created an opportunity for media coverage. It involved two days of celebrations including a welcome lunch, expert panels, a black tie dinner and guest speakers of national and international note.

A tour series of international and national chemists will take place across Australia from June to December. The tour guests include chemists who are involved in current chemistry research and development and are excellent communicators who help provide a link between chemistry and everyday life.

The annual National Chemistry Quiz this year is being held on 28 July. The quiz has been held each year since 1984. It is a unique chemical education activity that has become a truly international event with quiz papers being translated into seven different languages and distributed to more than 115 000 Year 7–12 students throughout Australia and in 14 neighbouring countries.

The Australian National Chemistry Quiz promotes the study of chemistry in schools and is the flagship event of National

The Polish-French chemist, Marie Curie, with her daughter Irene Joliot-Curie. Born in Warsaw in 1867, Curie worked on radioactivity, a term she coined to describe the rays given off by uranium. Her research coincided with that of Rutherford and Becquerel in showing that there were three different types of radioactivity: alpha, beta and gamma. In 1903 she won the Nobel Prize for physics with her husband Pierre for their studies in radioactive radiations. In 1911 she won the Nobel Prize for the second time, in chemistry, for the discovery of two new elements, radium and polonium. She died in 1934 of leukaemia caused by overexposure to radioactive radiation. Irene followed in her mother's footsteps and, with husband Frederic Joliot, was awarded the Nobel Prize for Chemistry in 1935 for their discovery of artificial radioactivity [credit: Acme Photo, courtesy AIP Emilio Segre Visual Archives, Brittle Books Collection] [A feature article on Marie Curie will appear in the next issue of *Australian Physics* – Ed].

Chemistry Week. The 2011 Chemistry Week in July is the most ambitious, comprehensive and accessible ever organised, with various chemical competitions for school students and the public as well as displays, lectures and debates centring on chemistry.

National Chemistry Week is backed up by Australia's largest national festival – National Science Week – in August. National Science Week promotes science to everyday Australians with more than 1000 events that reach an audience of more than one million people. The week's activities have a distinctly chemical flavour.

In a further move to bring chemistry to the public's attention, five travelling exhibitions are being rolled out across each state. The exhibitions are being displayed at libraries throughout the country to demonstrate the impact and application of chemistry in daily life. The exhibitions show how chemistry is fundamental to our most basic needs – from the food we eat, the water we drink and the air we breathe – to why chemistry is critical in solving our most vexing global problems involving food, water, health, energy, transportation and manufacturing.

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In an IYC 2011 initiative that looks set to involve millions of school students, an experiment called 'Water: a Chemical Solution' is being conducted throughout Australia and the world. The initiative is uniting students around the globe and highlights the role that chemistry plays in issues of water quality and purification. Students are conducting experiments on water quality and water treatment – acidity, salinity, filtration and solar still water purification – and reporting their findings on an online map so that results can be compared globally. The results will showcase the world's biggest ever chemistry experiment.

Back at home, Australian artists are joining with chemists to produce one of the more distinctive works staged for the IYC 2011. In an extraordinary artistic, historical and scientific collaboration, a unique interpretation of each element of the 2010 IUPAC periodic table is being created for the IYC Australia 2011 celebrations. The partnership works by chemists providing information on each element including its discovery, history, how it exists in nature and its modern day uses. Australian artists then interpret the information to produce individual prints of each element to ultimately create a full periodic table.

In one of the final events of IYC 2011, Australia's best and brightest chemistry researchers and educators are being celebrated at a gala function for the RACI National Awards in Melbourne in November. The awards will honour education excellence, in line with the long-standing practice of celebrating scientific research excellence, and will round off the full program of events for 2011.

The events and activities being held throughout the country ensure opportunities for participation in the IYC 2011 by the scientific sector, business and stakeholders, students and the public at local, regional, national and international levels.

Chemistry affects all of our lives and our future, so it's certainly the right time for us to get involved in celebrating the IYC 2011.

For more information on the IYC Australia 2011 events visit www.iyc2011.org.au. Katrina Beikoff prepared this article on behalf of the Royal Australian Chemical Institute. A similar version appeared in the February 2011 issue of *Chemistry in Australia*. Reproduced with permission.

Branch News

South Australian Branch Report

In the past 12 months the SA branch of the AIP has held seven lectures, five of them public. The first was the 2010 Gold Bragg Medal Presentation and Lecture on 6 May 2010. AIP President A/Prof. Brian James presented the medal to Dr Clancy James (Radboud University, Nijmegen, The Netherlands) for his PhD at the University of Adelaide. Clancy then gave a public lecture on his thesis 'Looking for the highest energy particles in nature using the Moon and radio-telescopes'. His PhD project was to investigate how to best use Earth-based radio telescopes to detect the very short radio pulses (lasting only a few billionths of a second) produced when ultra-high energy cosmic rays and any accompanying neutrinos hit the Moon.

In June 2010, on the eve of the soccer world cup, Professor Derek Leinweber of the University of Adelaide gave a public lecture on 'Turbulent Times – the Science of World Cup Soccer Balls'. He explained the physics secrets surrounding soccer-ball aerodynamics, including: How does a soccer ball suddenly dip beneath the goal's cross bar? What are the secrets to bending a soccer free kick? What makes a cricket ball swing? How does reverse swing work? What is contrast swing? Do golf balls really experience lift as they cut through the air? Finally, relevant to the current World Cup, Prof. Leinweber explored the aerodynamics of the Teamgeist and Jabulani soccer balls through numerical simulations and animations.

Two lectures were held on successive days in National Science Week. On 17 August Prof. Hans Bachor (ARC Centre of Excellence for Quantum-Atom Optics, ANU) gave a 'Laserfest' lecture on 'Lasers: 50 years young with a brilliant future'. Fifty years ago the first laser sent out the first pulse of light, but the laser is now a common underlying technology in many systems. Prof. Bachor addressed the questions: How does it actually work? Why is it so powerful? What might the future bring?

On the following evening Professor Elizabeth Winstanley (University of Sheffield, UK) gave the South Australian lecture in the AIP 2010 Women in Physics Lecture Tour, entitled 'Mini Black Holes at the Large Hadron Collider'. Winstanley discussed why one consequence of 'brane world models' is that copious numbers of mini black holes may be formed by collisions at the Large Hadron Collider (LHC) at CERN. She described how these mini black holes are created, and what happens to them once they have been produced. In particular, she discussed why these black holes will not swallow up the entire Earth. Prof. Winstanley presented the Claire Corani awards – for the best second-year female physics student at each SA University – to Namsoon Eom (University of South Australia), Rhiannon Murrie (Flinders University) and Phiala Shanahan (University of Adelaide).

At the annual joint meeting with the Astronomical Society of South Australia on 1 September, Dr Robert Crain (Centre for Astrophysics & Supercomputing, Swinburne University of Technology) spoke on 'Simulating the cosmos'. Crain discussed how computing has revolutionised theoretical studies of the formation of galaxies and the cosmic large-scale structure. He presented successes from recent flagship studies in which he had been involved. He also discussed how Australia is poised to assume a leading role in computational astrophysics throughout the next decade. The talk was illustrated with impressive movies produced by computer simulation.

On 30 September Professor Jim Piper (Macquarie University) pre-

Montage of Professor Elizabeth Winstanley (centre right) presenting the Claire Corani awards to Namsoon Eom, Rhiannon Murrie and Phiala Shanahan.

sented a second Laserfest public lecture on 'Laser Applications in Medicine'. Piper introduced the way light interacts with living tissue and organisms, and showed how this influences the way lasers are applied in a variety of therapeutic and diagnostic techniques, ranging from ophthalmology to the detection of pathogens in drinking water.

On 26 October Dr David Lingard (Defence Science and Technology Organisation) gave a technical lecture on 'Evaluation of the Effectiveness of Machine-based Situation Assessment'. This involves using a computer to perform situation assessment to assist human operators in comprehending complex situations. The evaluation technique is an iterative one that utilises a metric to measure the divergence between the situation assessment and the 'ground truth' (ie. what is actually there) in a simulation environment.

The AGM and annual dinner were held on 18 November. The after-dinner speaker, Professor Anthony Thomas (Elder Professor of Physics, University of Adelaide) spoke on 'Reflections on recent experiences at Jefferson Lab and the development of particle physics in Australia'.

During 2010 the education subcommittee was again very active. We thank Brian Parsons for organising the Super Science Quiz on 19 August. The winning school was St Peters College. We thank the Adelaide Chapter of the Young Scientists of Australia and Flinders University students for assisting with marking the quiz. The AIP-SA Excellence in Physics Teaching Award for 2010 (co-sponsored by Engineers Australia, SA Division) was presented at the SA launch of the National Science Week to Ms Anne Disney of Darwin High School, NT.

The branch again held a mid-year dinner at which most of its awards were presented. These included Silver Bragg medals for the best third-year physics student at each university, presented to Aidan

Montage of Branch chair Dr Giuseppina Dall'Armi-Stoks presenting the Silver Bragg medals to Aidan Cousins, Emma Langhans and Lachlan Larsen.

Cousins University of South Australia), Emma Langhans (University of Adelaide) and Lachlan Larsen (Flinders University). An 'Outstanding Contribution Award', which was inaugurated in 2009 and is a perpetual trophy to be updated each year, was presented to Dr Olivia Samardzic for her outstanding contribution to the Branch, including many years on the committee (two as branch chair), much hard work on the education subcommittee, program chair for the 2008 AIP Congress and her work for many years on the SA and International Space Schools.

Laurence Campbell

NSW Branch News

On 22 March 2011 the NSW AIP Branch and the Royal Society of New South Wales held their annual meetings at the University of Sydney. The evening featured Dr Ragbir Bhathal on his topic of searching for very fast light flashes. Ragbir is the Project Director of the OZ OSETI Project, the longest dedicated search for extra-terrestrial intelligence in the optical spectrum in the Southern Hemisphere. He is an academic staff member of the School of Engineering at the University of Western Sydney and teaches engineering physics, project management, and radio and satellite communications.

Bhathal's research interests are in astrophysics, physics, physics education and Aboriginal astronomy. He has published several papers in international journals and a number of books, including six on astronomy, and has been a recipient of various awards that include the 1988 Royal Society of NSW Medal for services to science and research.

Bhathal opened his talk by saying that we should be searching for nanosecond laser pulse from ETI. He believes that ETI would have surpassed the radio or microwave threshold and gone on to use laser pulses for intergalactic communications. A nanosecond laser pulse has several advantages, he said. Apart from its directivity, a 10^{15} W or more nanosecond laser pulse would outshine its star by four to seven orders of magnitude. This pulse could thus be easily detected by present day optical telescopes equipped with fast response detectors. Because the telescopes are being used as photon buckets they need not be highly sophisticated. The fact that the National Ignition Facility in the US has been able to generate 10^{15} W laser pulses, although only for a few nanoseconds, lends credibility to the use the use of lasers as communication devices by ETI civilisations.

The optical search strategy has been used in a dedicated mode only for the last ten years. Four groups, three in the United States – Harvard & Princeton Universities, the University of California and the SETI Institute – and one in Australia, the OZ OSETI Project at the University of Western Sydney, have led the charge for the optical search strategy.

From left, Frederick Osman, Heinrich Hora, Ragbir Bhathal and John Hardie.

The search at the University of Western Sydney is the longest dedicated optical search in the Southern Hemisphere. Last year a group of Japanese scientists and engineers also joined the optical and microwave searches. However, to date no positive signals in the optical spectrum have been received. Although a laser-like signal was detected in 2008 by Bhathal emanating from the globular cluster 47 Tucanae, it was dismissed after a six-month search in the same region failed to confirm the detection.

Bhathal hopes to continue the optical search with a new dedicated one-metre telescope which is currently on the drawing boards. He also discussed the latest developments in the radio wave search strategy, which clocked up its 50 year anniversary last year. Other SETI programs under way include searching for the organic molecule glycine and for earth-like extra-solar planets, as well as the Kepler mission and the exploration of Mars and meteorites.

Bhathal ended his lecture by quoting from the great nineteenth century mathematician and physicist, Karl Gauss, who said that the detection of a signal from ETI "would be greater than the discovery of America". The NSW AIP Branch and the Royal Society of New South Wales thank Dr Ragbir Bhathal for his outstanding lecture.

Fred Osman

Tasmanian Branch News

Elizabeth Chelkowska is the new chair of the AIP Tasmanian Branch.

Elizabeth Chelkowska has been appointed chair of the AIP Tasmanian Branch. She has an MSc from Wroclaw University (1977) and a PhD in Theoretical Chemistry on the theory of molecular Auger spectroscopy from the University of Tasmania (1994), where she was later appointed to a number of academic positions. In 2009 Elizabeth became a Senior Scientific Officer (Air Modelling) at the Tasmanian Environmental Protection Authority in Hobart. She has been a very active member of the Tasmanian Branch, including a member of the AIP Women in Physics since 1998, a former chair (2001–02) and secretary (2003–09).

The Branch AGM in November 2010 was followed by a LaserFest public talk on 'Lasers in Medicine and Public Health' by Professor Jim Piper, DVC (Research) at Macquarie University in Sydney. Piper has been involved in laser research for most of his scientific career and talked at a level which was readily accessible to the general public.

Piper started with a brief description of laser principles and the classic paper by Maiman on the 'Stimulated emission from a ruby crystal' which appeared in the August 1960 edition of *Nature* **187**, 493. Development was rapid, with publications on second-order lasers in 1961 and semiconductor lasers the following year. A few

words on the absorption characteristics of water and blood and the talk then jumped to applications ranging from the use of CO_2 lasers in general surgery, laser lithotripsy to the break-up of gall stones, kidney stones etc., and laser microsurgery in which blood vessels can be joined in a minute or so compared with the much longer time taken for conventional techniques.

But that was far from all. Lasers can be used for skin resurfacing, for tattoo removal, for laser dermatology and for therapy for pigmented lesions and photodynamic therapy. A photosensitive drug which accumulates preferentially in high blood flow areas, such as cancerous growths, can be used as a target for laser irradiation of the affected tissue.

In ophthalmology, pulsed excimer lasers can be used in retinopathy, cataract surgery and corneal scalping. In dentistry, lasers can replace drills and be used for teeth whitening. Finally, in a quite unexpected twist, Professor Piper described how his laboratory was contracted to drill the precision holes – at 63.5 ± 0.5 µm – needed in the torches for the Sydney Olympic Games.

The first of the Branch's public lectures for 2011 was presented on 17 March by Professor Robert Lysak from the University of Minnesota. His topic on 'The Physics of the Aurora' was appropriate now that auroras of the new solar cycle are beginning to be visible in Tasmania. The well-illustrated treatment was at a level easily understandable by those in the audience who might be unfamiliar with interplanetary and terrestrial magnetic configurations.

The lecture opened with clear descriptions and images of the various types of aurora that can be observed, such as diffuse, discrete auroral arcs, twists and folds, auroral curls and spirals, and other types. A movie taken from the space shuttle showed rays to altitudes of 1000 km.

Professor Lysak then went on to discuss the main atomic transitions in oxygen and nitrogen that produce the colours in the aurora, before describing that the auroral oval in both hemispheres is the electrical footprint of a global electrical current system. He briefly mentioned how magneto-hydrodynamics leads to Alfvén waves and hence acceleration of the particles involved.

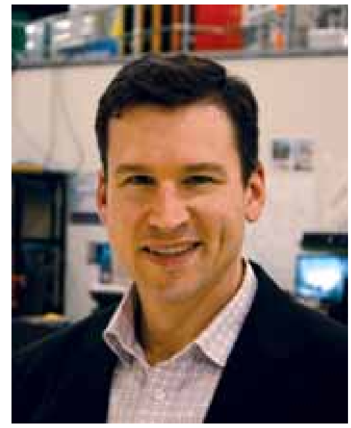
Lysak ended by describing how most of charged particles that give rise to the aurora are initially stored in the geomagnetic tail, being released when the magnetosphere is distorted due to the arrival at earth of a coronal mass ejection.

John Humble

Victorian Branch News

Dr Andrew Stevenson is the new chair of the Victorian Branch. Andrew completed his PhD in physics at the University of Melbourne in 1983 and joined CSIRO where he is now a Principal Research Scientist at the Division of Materials Science & Engineering in Clayton, Victoria. He serves on various committees, including the Australian Synchrotron User Advisory Committee, and is an Associate Editor of *Medical Physics*.

Andrew was awarded a CSIRO Medal in 1998 as part of the team responsible for the development of phase-contrast X-ray imaging methods using laboratory-based micro-focus sources. This work has included making significant contributions toward the development of novel X-ray instrumentation, now being commercialised by a spin-off company, XRT Ltd. He is a co-author on two seminal *Nature* papers related to novel aspects of X-ray imaging, which have combined citations of over 1000.



Andrew Stevenson (left) is the new chair and Mark Boland is the new secretary of the AIP Victorian Branch.

Andrew's research interests are in the area of characterisation of materials by use of X-ray scattering, diffraction, innovative optics and imaging methods. This work has involved use of both laboratory X-ray sources and synchrotron facilities. He is also contributing to the design and development of the Imaging and Medical Beamline at the Australian Synchrotron and led the first experiments to be performed there in December 2008.

Dr Mark Boland is the new secretary of the Victorian Branch. Mark completed his PhD in photonuclear research measuring a new dipole state in the halo nucleus ^{6}He. He then completed a two-year postdoc at the MAX-lab at Lund University in Sweden on the nuclear physics beamline. While there he discovered the field of accelerator physics and upon completing his postdoc returned to Melbourne to work on accelerator systems at the Australian Synchrotron.

Mark is now a Principal Scientist in the Accelerator Physics Group and an Honorary Senior Research Fellow at the School of Physics, University of Melbourne, co-supervising students in the Experimental Particle Physics Group. He was instrumental in the creation of the Australian Collaboration for Accelerator Science (ACAS), bringing together the Australian Synchrotron, the University of Melbourne, ANSTO and the Australian National University, which aims to promote and grow the field of accelerator physics.

The first public lecture for 2011 was given on 31 March at Monash University by Dr Chris McNeill on the 'Physics of Organic Semiconductors and Devices'. Chris recently joined the Department of Materials Engineering at Monash, after five years with the opto-electronics group at the Cavendish Laboratory, Cambridge. His talk gave an overview of the physics of organic semiconductors and their device applications, highlighting differences compared with inorganic semiconductors, and also commented on present challenges for commercialisation.

Organic semiconductors, based on conjugated carbon-based molecules and polymers, have attracted significant interest recently as an alternative to traditional inorganic-based semiconductors. While organic semiconductors are unlikely to compete with their inorganic counterparts in terms of absolute device performance, the potential low-cost of manufacture of organic devices and their inherent mechanical flexibility opens up new areas for potential commercial exploitation. Technologies that have been, or are in the process of being commercialised, include plastic solar cells, flexible displays and printed electronic circuits.

[A feature article on Chris McNeill's research will appear in the next issue – Ed]

AIP Courses Accreditation Committee Membership

The AIP Courses Accreditation Committee is seeking new members to serve during the 2012–16 cycle of Australian and International Physics Course accreditations. The committee is currently chaired by Bob Loss, Registrar of the AIP, and consists of nominally two members from each state, plus the members of the AIP Membership Committee.

Australian universities that wish to maintain accredited programs are required to have them accredited every five years. The AIP Registrar plans each accreditation with each institution 12 to 24 months in advance and draws up a three-member accreditation panel for each accreditation from the committee membership. Each panel normally consists of one committee member from the state in which the institution is having programs accredited, one committee member from an adjacent state, and the Registrar, or experienced nominee from the committee, as chair of the panel.

For an individual accreditation panel member, Australian Accreditations involves previewing course and accreditation documentation provided by the institution being accredited in relation to the AIP Accreditation Standards. The panel then visits the institution for one day to meet with staff and students involved in these courses and to verify as much as is possible of what is provided in the documentation. The chair of the panel then drafts a report with the assistance of the panel members which is reviewed by a number of parties before the AIP president sends it to the institution.

In contrast to an Australian university, an international accreditation visit is typically five working days which together with travel time requires about one week of commitment. The average level of involvement required from an individual committee member is about three Australian accreditations per five-year cycle. International accreditations are normally undertaken by committee members with significant Australian accreditation experience. All travel and accommodation expenses are reimbursed or prepaid.

Participation in Physics Accreditation will interest individuals with experience in tertiary level physics education and in quality assurance and improvement processes in physics education. International accreditations involve additional considerations, such as undergraduate programs that provide support for local and regional as well as international needs, and teaching and learning physics within different cultural frameworks.

Nominees should be Members or Fellows of the AIP and have several years of teaching experience across all levels of undergraduate physics, as well as experience in program/management development within an AIP accredited program.

In addition to performing a valuable service to the Australian Physics community, Members who participate in accreditations report gaining significant insight into best practice physics teaching and are able to better assess their own courses and student outcomes.

If you are interested in becoming a member of this committee you should provide a CV to your State Branch President by Friday, 10 June 2011. The state branch will rank the applicants and forward its recommendation to the current committee, which will then make the final selection. If you are already a member of this committee there is no need to reapply. A workshop on Accreditation for all Committee members will be held in conjunction with the Australian Conference on Science and Mathematics Education to be held in Melbourne at the end of September 2011.

For further information, please contact Dr Bob Loss, Registrar of the AIP, at aip_registrar@aip.org.au.

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Quantum Optics – An Australian Perspective

Hans-A. Bachor

Quantum optics is a very active research field in Australia and across the globe. This article traces some of the history of how we got into such a strong position and discusses some of the opportunities ahead.

Fig. 1. The Dan Walls summer school on laser physics was held at the University of Waikato, New Zealand, in February 1986. The front row from the left includes David Pegg, Carlton Caves, Marlin Skully, Carlo Tomesi, Dan Walls (in white jacket), Gerard Milburn (behind Walls), Mark Levenson and John Harvey.

Quantum optics encompasses any system that makes use of the quantum nature of light, from the generation of light, in particular with lasers, to its detection and the interaction with matter. Nowadays, the focus is very much on sensing applications and metrology below the limit imposed by quantum noise and the communication and processing of quantum information, which is in itself a very new field of science. Quantum optics is now entering the era of practical applications and commercialisation, with the leading practical example being quantum key distribution [1].

In parallel we have developed the ability to use coherent matter waves in very similar ways to coherent light. We now have atom lasers and atom interferometers, we use and build more accurate atomic clocks that have coherent atomic oscillators and we can record the quantum statistics of atoms in a similar way to photons. Here the breakthrough was the cooling of atoms to ultra-cold temperatures, approaching nano-Kelvin, and the Bose-Einstein Condensate, as a new state of matter. Recently we created and have begun to understand comparable coherent effects in fermions. Furthermore, several groups are also looking at electronic circuits and mechanical systems at the quantum noise limit. Quantum technology can now be discussed with confidence [2].

Australia is extremely active and successful in all of these topics. We now have a large number of active research groups, excellent support through several ARC Centres of Excellence (COE) in the first and second generation, and an outstanding international reputation. Around the world our colleagues are astounded of our creativity in producing a noticeable fraction of all the publications and this field. All of these set the foundations of future quantum technologies where Australia is capable of playing a significant role. Similarly, Australian studies of research quality and research output show quantum science as one of the highlights [3].

"Dan Walls created an outstanding school for theoretical quantum optics, leading to a generation of successful scientists that is now the backbone of the current research field."

A bit of history

Australian leadership has not always been the case – the field is young and in our country it expanded rapidly. In the mid 1980s the field was still dominated by theory. The major questions were: what is the impact of nonlinearities on the quantum properties of light and can we modify the photon statistics? There was a competition for the first generation of nonclassical, or squeezed, continuous light, almost exclusively in the US. Entangled single photons had been demonstrated through the famous Bell experiments in France, but the interference of single photons was still an experiment for the future. The focus at that time was to understand and demonstrate

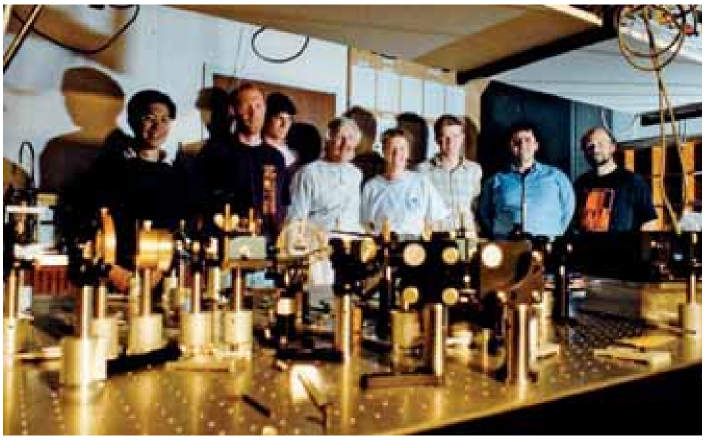

Fig. 2. Quantum optics team at the ANU in 1994: From left: Ping Koy Lam, Robert Batchko (Stanford), Ben Buchler, Hans Bachor, Eleanor Huntington, Daniel Shaddock, Charles Harb and Tim Ralph. Shown are the components of an experiment demonstrating phase sensing below the quantum noise limit.

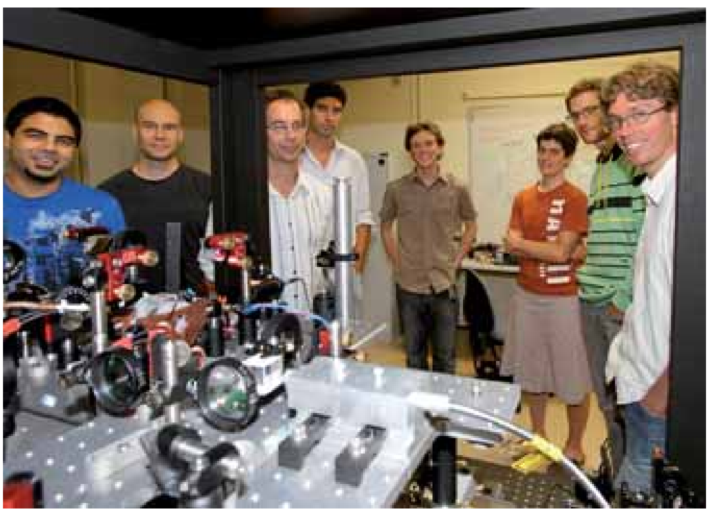

Fig. 3. The Rb Atom laser team at ANU in 2010 that is developing the technology for a practical atom interferometer with enhanced sensitivity. The devices are becoming more reliable and more precise with each generation. From left: John Debs, Mattias Johnsson, John Close, Paul Altin, Gordon McDonald, Rachel Poldy, Daniel Döring and Nick Robins.

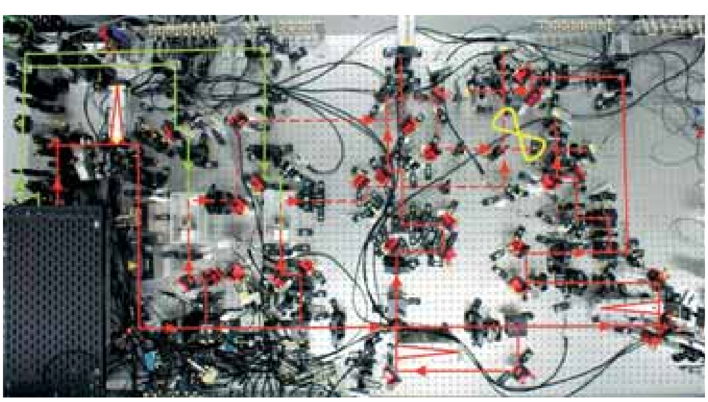

Fig. 4. EPR entanglement in the real world – not a quantum paradox but the foundation of future technology. This apparatus creates optical beams which perform better than the best laser and demonstrate spatial entanglement, the correlation of the position and direction of the laser beams better than the conventional Heisenberg Uncertainty limit (see [7] for details).

these quantum effects, to develop new techniques and find new materials that could create the required nonlinear response, to measure quantum statistics, and confirm theory predictions.

Under the leadership of Dan Walls and Crispin Gardiner, New Zealand had become a hub for quantum optics, while conventional laser technology was very active in Australia at the ANU, Macquarie and Auckland and, similarly, conventional spectroscopy included the CSIRO and Melbourne, ANU and Dunedin. The famous Quantum Optics summer schools [4] had become a mecca for young scientists from this region, allowing us to meet leading researchers from across the globe. Dan Walls created an outstanding school for theoretical quantum optics, leading to a generation of successful scientists that is now the backbone of the current research field (see Fig. 1).

By this stage the team led by myself at ANU focused on experimental projects, complementary to the strong theory activity in NZ. Building on the Australian expertise on spectroscopy and importing techniques from the leading labs, at that stage almost exclusively based in the US, experiments on squeezing were performed initially with barium atomic beams, then second harmonic generators and optical parametric oscillators, using nonlinear crystals. By 1996 the work by Ping Koy Lam, Tim Ralph, Andrew White, Charles Harb, Eleanor Huntington and others were considered world class and we gained international recognition. In parallel, the ANU work on using squeezed light evolved, in particular for gravitational-wave detection with numerous contributions by David McClelland, Ben Buchler, Malcolm Gray, Daniel Shaddock and others. Fig. 2 shows a scene from these days in 1994 at the ANU – with one of the table top experiments that demonstrated optical sensing below the quantum noise limit.

Building the technology in photon and atom optics

The quest of breaking the quantum noise limit in any form made optical sensing, the design of better lasers and better instruments the major driver. We helped in perfecting the techniques and to make them reliable. The theory teams were part of the emerging ideas of quantum control and quantum information processing. This Australian know-how has now been exported to several leading groups in Europe, US and Asia. Two textbooks were written in Australia, one on the practical aspects of quantum optics [5] and one on the theoretical foundations of quantum optics [6] and both are widely used around the world.

In parallel, the ANU team created the first ultra-cold atoms in a magnetic optical trap and investigated the diffraction of matter waves. The Otago team of Andrew Wilson and Robert Ballagh was the first to create a Bose-Einstein Condensate in the Southern Hemisphere, as was then the catchphrase, soon followed by the ANU team led by John Close, next at Swinburne by Peter Hanaford's group, and then again at Queensland by Halina Rubinsztein-Dunlop's group.

We now had in atomic physics a source of coherence and a starting point for more complex systems base on coherent matter waves (see Fig. 3). The way was open to build devices that are closely analogous to devices in optics – we can propagate and focus matter waves, build beam splitters and interferometers, build atom lasers and have full control of the coherent beam of atoms. Refined theories had to be developed to take into account the complex non-

linear properties of these quantum systems, to include and exploit the wealth of properties BEC exhibit at the condensation point, and more recently to include the properties of samples of fermions at ultra-cold temperatures.

In optics, the emphasis shifted to experiments using single photons, which had significant technical advantages, and were also encouraged by the development of the concepts and ideas of quantum entanglement. Around the world the importance and capability of q-bits were analysed, the mathematical link between complex calculations and the evolution of quantum systems were discovered, and this led to the predictions for quantum computing.

In particular, interest in fast factorisation, with all its implications for cryptography, code breaking and other security application, caught the attention and created the new, rapidly expanding field of quantum information theory. The big questions became the quality of the entanglement, the ability to teleport information from one place to another, the quest for scalability to many q-bits and practical error correction.

Fig. 5. Members of ACQAO and of the advisory board in 2010 at the ICAP2010 conference in Cairns. This event, and parallel conferences before and after, created a major forum for discussions and planning of future scientific work.

"This Australian know-how has now been exported to several leading international groups in Europe, US and Asia."

Many suggestions were made as to how this could be realised experimentally and what a truly practical system would look like. Australia became a leading force in developing one particular approach: phosphor atoms imbedded in precise positions in silicon were the medium of choice. This was later complemented by a major effort to utilise optics based on entangled photons [7] – see Fig. 4.

The era of quantum technology

In 2002 the opportunity arose to increase the speed of research, to form more effective collaborations across Australia and to link the many groups that had formed from the humble beginnings in the 1980s. Centres of Excellence are the logical extension from individual projects. They enhance the strength of individual scientists, much like an orchestra enhances the sound of soloists and creates more powerful sound effects. It is the joint creativity of the group of individual scientists that make the difference.

A formidable trio of Centres of Excellence in Quantum Science was created. The Australia Centre for Quantum Atom Optics (ACQAO), directed by myself, combined both coherent optics and coherent matter waves based on the BEC to investigate the concepts and practicalities of macroscopic entanglement of many particles, photons and atoms, both bosons and fermions [8]. The centre linked research at the ANU, Queensland and Swinburne. Fig. 5 shows many of the members of the current centre.

Similarly the Centre for Quantum Computing Technology (CQCT) [9], led first by Robert Clark and now Michele Simmons, combined the techniques for creating quantum computing systems in silicon at UNSW and Melbourne University with optics and

theory at Queensland and Griffith. And the Centre for Ultrahigh bandwidth Devices for Optical Systems (CUDOS), led by Ben Eggleton, has focused on the classical aspects of optical communication systems combining the strengths of Sydney University, the ANU and Swinburne.

For the past eight years these three centres have created tremendous progress and output, have established the field in the wider community and have created the international recognition we now enjoy. At the same time other teams have been established. More universities have invested in this field, in particular Macquarie, Monash, UWA, Sydney and Adelaide in optics. A major force in the physical sciences in Australia has been created with at least 40 groups, some supported and operating individually, and others as part of three active Australian Research Council sponsored Centres of Excellence.

Future opportunities

We now have developed the platform made of fully functioning devices and comprehensive theory that allows us detailed modeling – to consider the design of machines that can be deployed. While still complex and based in University laboratories across many laboratories in Australia and around the world.

The progress in quantum optics has been in two directions: quality and reliability, both allowing complexity. These are two requirements for future practical applications. In order to make the quantum effects as strong as possible, and at the same time robust, we need machines that have very high efficiencies and stay tuned for long times. We will have to combine many quantum systems, or in information language q-bits, to build machines that can perform complex tasks, eventually outperforming their classical counterparts. Fig. 6 illustrates the trends of both photon and atom optics in these directions.

"History shows that new insights, such as the quantum statistics of light and atoms, will always find amazing and unforeseen applications."

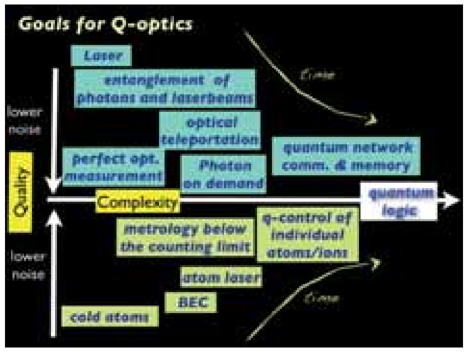

Fig. 6. A schematic of the progress in quantum optics over time (from left to right). The devices we built improved in quality, and that means they show less noise, and are more reliable, and that means they can become more complex.

Starting from simple systems, such as the laser or an ultra-cold atomic ensemble of atoms, we have seen dramatic improvements in reliability and complexity. We can now build machines that include multiple entangled states of light on the one hand and have fully controllable stable matter waves on the other [8]. Photon and atom science are starting to approach each other and other quantum systems such as quantum circuits, opto-mechanical and all solid state systems will be some of the many technical platforms for quantum applications.

Within a few years these devices will be robust enough for practical applications of quantum information processing. Using new protocols that quite likely have not even been invented yet, these machines and processes will become widespread technology. At the same time metrology will continue to make further advances allowing major improvements in sensitivity and accuracy. The ability to make better measurements has always been a key resource. It allows us to develop new instruments, to gather better data, to test improved models and predictions and to find new ways of shaping our world. We will discover new effects in fields as diverse as geodesy, materials science, medical imaging and astronomy with the improved accuracy.

The details and how widespread these applications will become remains pure speculation at the moment. But we can address a range of questions: How useful and universal will quantum computers be? Are there other practical uses of quantum information? Will we be able to understand and avoid decoherence? Can we emulate important effects, for example, in superconductors or in bio-molecules using quantum systems? What are the ultimate limits in metrology? Have we overlooked important implications of quantum science?

History shows that new insights, such as the quantum statistics of light and atoms, will always find amazing and unforeseen applications. Australia has already made remarkable contributions – and our very strong research effort will ensure that we can remain one of the key players in this emerging field of technology. We can be proud about the past and confident about a bright future.

[A profile of Hans Bachor by Ben Villani appeared in our previous issue *AP* 47(5) (2010) 105]

References

[1] See for example the Quintessence company at www.quintessencelabs.com.

[2] See e.g. P. Trute, 'Computing with a single electron', *Aust. Phys.* **47**(4) (2010) 84. See also www.arc.gov.au/ncgp/ce/engineered_quantum_systems.htm.

[3] The most recent Australian Research Council study of research excellence in Australia is at www.arc.gov.au/era/outcomes_2010.htm.

[4] J. Harvey and D. F. Walls (eds), 'Proceedings on Quantum Optics' (Springer, Berlin, 1989).

[5] H.-A. Bachor and T. C. Ralph, 'A guide to experiments in quantum optics', 2nd edn (Wiley, New York, 2003).

[6] D. F. Walls and G. Milburn, 'Quantum Optics', 2nd edn (Springer, New York, 2008).

[7] K. Wagner, H.-A. Bachor *et al.*, 'Entangling the spatial properties of laser beams', *Science* **321** (2008) 541. For the latest results see B. Hage *et al.*, arXiv 1103.4199v2.

[8] For recent information on ACQAO, see www.acqao.org.

[9] For recent information on CQC2T, see www.cqc2t.org/home.

Samplings

Don Price

Kepler spots six planets orbiting a star

physicsworld.com/cws/article/news/45011

A Sun-like star with six orbiting planets has been discovered by the Kepler spacecraft in what NASA researchers are proclaiming as the biggest discovery in their field since the first exoplanet was discovered in 1995.

The six new planets have been located over 2000 light-years from Earth orbiting a star roughly the same size as our Sun, which has been named Kepler-11. The planets were discovered by the transit method, which can detect a slight dimming in the light of a star as a planet sweeps across our line of vision from Earth. Prior to this finding, only one star was known to have more than one orbiting planet – Kepler-9, discovered last year, which has two confirmed planets and possibly a third.

By measuring the 'depth' of each transit, which indicates how much starlight dims due to a transiting planet, the researchers were able to calculate the mass and radius of the each planet. In this way, they were also able to obtain the bulk density of each planet, which is already yielding clues to their compositions.

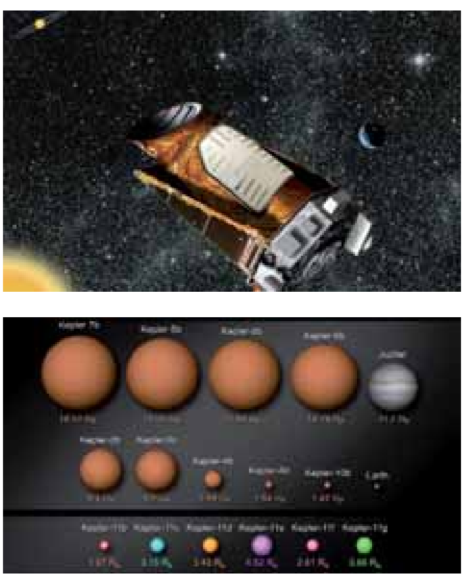

Fig. 1. Artist's impression of the Kepler spacecraft (above) and the exoplanets discovered by Kepler to date (below).

The six planets range in size from twice Earth's radius to more than four times as large as Earth, and the researchers describe them as being relatively 'puffy', having fairly large radii for their masses. They suggest that the planets probably lie somewhere between the densities of Earth and Neptune, and the inner two planets may well be made from rock and water with a steam atmosphere. The discovery is detailed in a paper in *Nature* (www.nature.com/nature/journal/v470/n7332/full/nature09760.html).

Earth grew from 'candy floss' rocks

physicsworld.com/cws/article/news/45567

The earliest rocks in the solar system, from which the terrestrial planets were born, were more like candy floss than hard rock, according to a new analysis carried out by a team led by Philip Bland from Imperial College, London, and including researchers from Curtin University and CSIRO in Australia. This is the first geological evidence to support the idea that the first solid material in the solar system was extremely porous before it was subsequently compacted into larger bodies, which become the planets we know today.

To get an idea of the type of primitive material that surrounded our young Sun, astrogeologists often look to the belt of asteroids that orbits between the paths of Mars and Jupiter – objects that did not coalesce into planets. These asteroids provide us with meteorites, including a class of rocks known as carbonaceous chondrites, which contain well-preserved material from the early solar system.

While geologists have scrutinised many of the chondrites that have fallen to Earth as meteorites, they have found it difficult to probe the internal structures because the grains are so fine. Bland and his colleagues analysed a sample from the Allende meteorite, which fell to Mexico in 1969, the largest carbonaceous chondrite ever discovered on Earth. They used the relatively new technique of electron back-scatter diffraction, which enabled them to resolve features of the grains' structures down to 0.3 μm in size.

Then, from these images, Bland's team invented a new method for quantifying the amount of compression that the rock has experienced throughout its lifetime in order to deduce its original structure. Using the method, the team found that the sample from the Allende meteorite used to be mostly empty space, with an initial porosity of 70–80%. The finding that this primitive rock had a very high original porosity matches well with recent computer models that predict that the seeds of planets (planetisimals) in the early solar system emerged from turbulence in the disc of dust that surrounded the young Sun. The research is reported in *Nature Geoscience* (www.nature.com/ngeo/journal/vaop/ncurrent/full/ngeo1120.html).

To solidify, just add water

physicsworld.com/cws/article/news/45174

Scientists in Germany have shown that a suspension of particles can be transformed from a viscous fluid to an elastic gel by adding a small quantity of a second liquid – as long as the second liquid does not mix with the bulk fluid. They say that the second liquid binds the particles more tightly together, and found that this enhanced binding takes place even when the liquid itself adheres poorly to the particles. Applications of this work, say the researchers, include lighter and cheaper foams as well as improved manufacturing of paints and other suspensions.

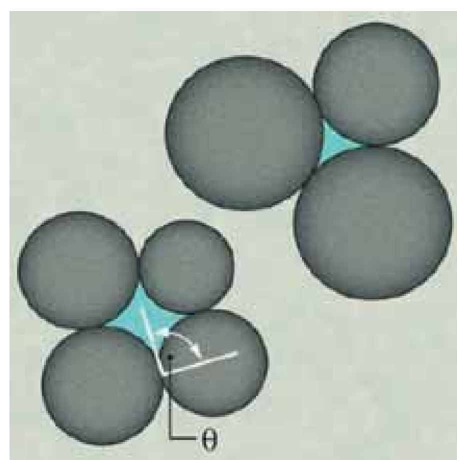

Fig. 2. Diagram showing the capillary state whereby the second, non-mixable fluid (blue) causes particles to stick together.

Being able to control the flow of suspensions – small, solid particles dispersed in a fluid – is important in the manufacture of many commercial products, such as coatings and foodstuffs. For example, it is better if paint is less viscous when it is being mixed during production, but more viscous when in its finished state so that it sticks to walls and does not drip.

In the latest research Erin Koos and Norbert Willenbacher of the Karlsruhe Institute of Technology have demonstrated a new and practical method for adjusting the viscosity of a suspension. In their experiment, they first dispersed hydrophilic (or water-attracting) glass beads, each about 25 μm in diameter, into an organic solvent. Then they added water to this suspension so that it made up just 1% of the suspension by weight. When they stirred, the initially viscous fluid transformed into a gel-like material.

This transformation has been known about for many years, and occurs because the water wets the particles – in other words, it tends to adhere to the surface of the hydrophilic particles more readily than does the organic liquid and so forms a thin film around them. When two particles get close enough, the water's surface tension then dictates that it becomes energetically favourable for the coatings of water to join up and form a bridge, so binding the particles together and creating a network that makes the suspension more rigid.

What the researchers also found, however, was that the reverse can happen. When dispersing hydrophobic (water-repelling) glass beads into the solvent and then adding 1% water, they discovered that the initially viscous suspension becomes gel-like upon stirring. In other words, adding a small quantity of a substance that wets less well than the solvent, rather than better, also binds the beads together to form a more-or-less rigid network.

This process has also been observed before. For example, adding water to melted chocolate causes the latter to solidify even though the solvent in the chocolate – cocoa butter – wets the cocoa particles more readily. What Koos and Willenbacher have done is to demonstrate that this is a general phenomenon, having subsequently found that the process occurs in a wide variety of fluid and particle combinations. They were also able to pin down the mechanism responsible, and show that it is essentially the same process as occurs when introducing a superior wetter, but in reverse.

The research is published in *Science* (www.sciencemag.org/content/331/6019/897) where there is also a Perspective article by Butt (www.sciencemag.org/content/331/6019/868.full).

Human genome tenth anniversary

In February 2001, *Science* and *Nature* published two papers that provided the first detailed look at the nearly complete sequence of the human genome. *Science* contains a special month-long series celebrating the tenth anniversary of that momentous achievement, including News features and brief essays that explore the impacts of the genomics revolution on scientists and society. All the articles are in the 4 February issue of *Science* (links to all the articles may be found at: http://www.sciencemag.org/site/extra/genomeanniversary/).

Thermal Casimir force seen for the first time

http://physicsworld.com/cws/article/news/45048

The thermal Casimir force – whereby two objects feel an attraction caused by thermal fluctuations of the electromagnetic field – has been measured for the first time by physicists in the US. The tiny attractive force was detected between two gold surfaces separated by at least 3 μm. This is too far apart to have been due to the more familiar Casimir force that arises from quantum zero-point fluctuations.

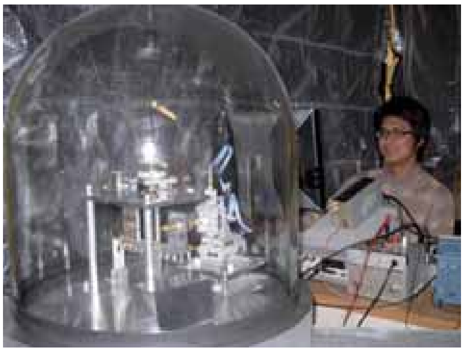

Fig. 3. The thermal Casimir force experiment at Yale is done under an evacuated bell jar. Yale physicist Andy Kim (now at Seattle University) is on the right.

The Casimir force owes its name to the Dutch physicist Hendrik Casimir, who in 1948 worked out that two uncharged, perfectly conducting metal plates placed in a vacuum should be attracted to one another. This force arises from the fact that the energy of an electromagnetic field in a vacuum is not zero but continuously fluctuates around a certain mean value, known as the 'zero-point energy'. Casimir showed that the radiation pressure of the field outside the plates is slightly greater than that between the plates. As a result, the plates will experience an attractive force.

Whereas zero-point fluctuations occur at temperatures right down to absolute zero, an electromagnetic field also experiences an increasing number of thermal fluctuations at higher temperatures. In 1955 the Russian physicist Evgeny Lifshitz predicted that these fluctuations should have a similar effect on radiation pressure, leading to a thermal Casimir force.

Steve Lamoreaux, who in 1997 was the first to measure the Casimir force, has now teamed up with Alexander Sushkov and colleagues at Yale University to measure the thermal Casimir force for the first time. Instead of using two parallel plates, the team looked for the force between a gold-coated plate and a sphere. After correcting for the residual electrostatic forces between sphere and plate, due to imperfections in the gold surfaces, Sushkov and colleagues found that the zero-point Casimir force dominated, as expected, at separations of less than about 3 μm. However, at greater distances, where the zero-point force is expected to drop off rapidly with the inverse cube of the separation, the team measured a force that fell more slowly with the inverse square of the separation. The work is published in *Nature Physics* (www.nature.com/nphys/journal/vaop/ncurrent/full/nphys1909.html).

Don Price is with CSIRO's Division of Materials Science and Engineering at Linfield, NSW.

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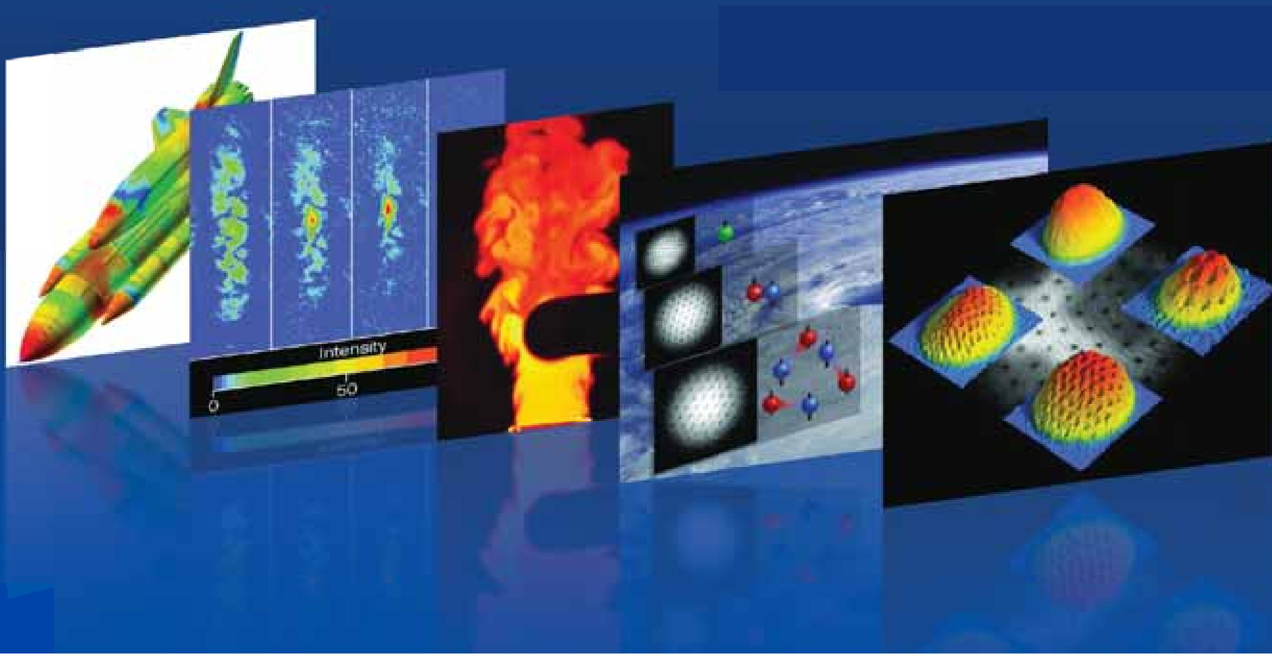

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LIGO-Australia: Quantum Mechanics meets Cosmology

Jesper Munch (University of Adelaide), David Blair (University of WA), Duncan Galloway (Monash University), David McClelland (Australian National University), Andrew Melatos (University of Melbourne) and Stan Whitcomb (LIGO Laboratory at Caltech and UWA)

The next decade will see an unprecedented alignment between science at the largest scales and at the smallest. A new generation of gravitational wave detectors, designed to probe the secrets of the Universe at the largest of scales, will do so by reaching the fundamental quantum limit for measurement, measuring the positions of everyday objects (mirrors with masses of tens of kilograms) at the Heisenberg limit over multi-kilometre baselines. And Australia is poised to play a critical role in this quest.

We stand on the brink of an extraordinary opportunity to build a state-of-the-art experimental physics facility in Australia. Discussions are currently under way to determine if we are able to accept an offer of collaboration with the US-based Laser Interferometer Gravitational Observatory (LIGO) Laboratory to build one of its next generation detectors ('Advanced LIGO') in Australia. If approved we would be building one of the most advanced experimental physics facilities in Australia, providing a major, transformational boost for teaching and research in physics, cosmology and eventually astronomy.

The detector itself is a 4 km long Michelson interferometer optimised to the fundamental quantum limits of position measurement, necessary for routine observations of gravitational waves. To reach the sensitivity required, the detector will be enclosed in the largest ultra-high vacuum system in the Southern Hemisphere while using the most precise optical components, the most advanced suspension systems, the highest power, ultra-stable laser available and very advanced computational data analyses approaches.

As will be discussed below, the sensitivity required for routine detection is a relative change in arm length of the order of 10^{-19} m, or 10^{-4} times the diameter of a proton! This astonishing requirement is met using large macroscopic mirrors, or test masses, themselves made up of individual atoms. The experimental challenge is extraordinary, but with more than a decade of development, the required sensitivity now appears to be a feasible goal. In close collaboration with the international community, Australia could be a leading player in this most important emerging experimental field.

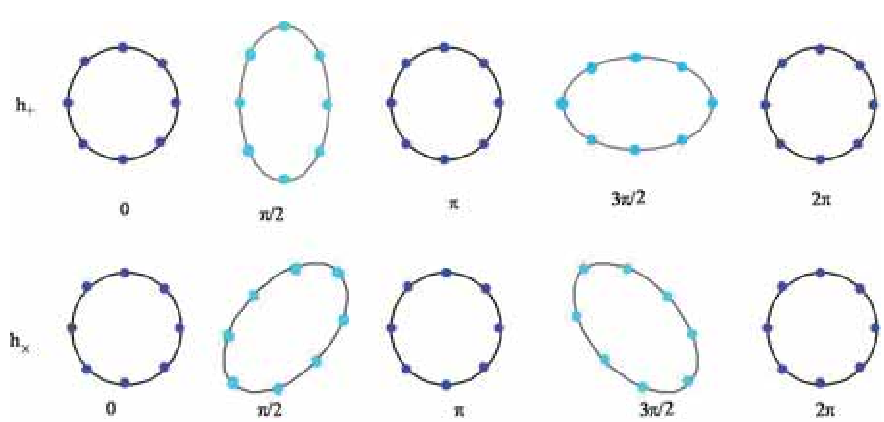


Fig. 1. Gravitational waves distort space-time between masses. A gravitational wave impinging on a ring of free masses in a plane perpendicular to the direction of travel alternately stretches and squeezes space itself, causing the circle of masses to distort into an ellipse alternating along the two axes. Gravitational waves exist in two identical polarisations rotated by 45 degrees around the direction of propagation. The direction of polarisation provides important astrophysical information.

A primer on gravitational waves

Gravitational waves were predicted as a necessary consequence of Einstein's general theory of relativity nearly 100 years ago, but have never been directly observed. They are a consequence of the finite speed (the speed of light) by which information about gravity can propagate, analogous to the way electromagnetic radiation carries information about accelerating electric charges. However, unlike electric charges (which come with two signs), mass is always positive, and dipole gravitational waves can therefore not exist: the lowest order form is quadrupole radiation. To date, gravitational waves have not yet been directly observed. Nonetheless, the existence of gravitational waves has already been confirmed to the satisfaction of the Nobel Foundation which awarded the 1993 Nobel Prize in Physics to Russell Hulse and Joseph Taylor for showing that the rate of decay of the orbit of a binary pulsar system was correctly explained by the emission of gravitational waves calculated using Einstein's theory.

In relativity, static gravitational fields are described by distortions of space-time, and gravitational waves are described by an oscillating transverse strain in space which propagates at the speed of light. A gravitational wave passing through a circle of test masses (Fig. 1), separated by a distance L, would cause a measurable deformation ΔL of the circle into an ellipse, determined by the strain amplitude of the wave, $h = \Delta L/L$. But since gravity is very weak compared to other fundamental forces, the accelerating mass required to produce a measurable gravitational wave is huge, and the resultant strain produced by a gravitational wave on test objects on Earth very small.

The most likely sources of gravitational waves are thus cataclysmic galactic events,

for example in-spiralling binary neutron stars and black holes, having very large masses and high accelerations. Estimates of the number of known sources in the nearby Universe are uncertain, but show that a strain sensitivity of $h = 10^{-21}$ might allow a rate of observation of about once per ten or more years, whereas to make gravitational waves part of routine astronomy with at least a few events per month would require observations from a thousand-fold larger volume, and hence a sensitivity of 10^{-22}, or better.

While a direct observation of gravitational waves has been a long-sought quest, the justification for measuring gravitational waves directly is not limited to confirming Einstein's theory. More importantly, gravitational wave observations will be used as a whole new modality to investigate the Universe, ranging from cosmology and astrophysics to the fundamentals of the behaviour of matter at high densities. When two black holes revolve around each other, they radiate energy and move in ever tighter and faster orbits. The gravitational waves they produce will have the form of a chirp of increasing frequency and amplitude as the energy lost by the system grows, culminating in the coalescence of the two black holes into a single object. This chirping waveform can be detected directly by a network of detectors, and can be used to determine uniquely the masses and spins of the two black holes, the location on the sky, the orientation of their orbital plane and the absolute distance to the system.

Other phenomena are predicted to have different gravitational wave signatures and, combined with data from electromagnetic and neutrino observatories, will allow answers to fundamental questions ranging from general relativity to black hole phenomena, and to an understanding of nuclear matter at high densities. A major task has thus been the development of advanced computational models of expected signatures, and suitable protocols for extracting the information from weak and noisy signals. These many possibilities are discussed in detail in the Gravitational Wave International Committee (GWIC) roadmap (see below) and references therein [1].

The detection and integration of gravitational waves is thus a long term, fundamental scientific endeavour where it is expected that not only the predicted topics mentioned above will be investigated, but where whole new phenomena and discoveries will be made, similar to the revolution started with the invention of the telescope.

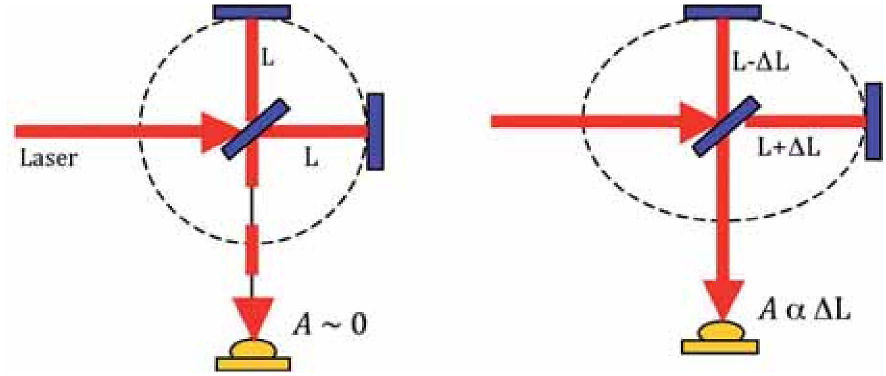


Fig. 2. Gravitational waves can be detected using laser interferometers to probe the distortion of space. The optics of a Michelson interferometer can serve as the test masses, resulting in a relative change of the lengths of the arms of the interferometer. The change in length results in a change in the transmitted light at A.

Detection of gravitational waves

Gravitational waves span as wide a range of frequencies as electromagnetic waves, with the audio range (10 Hz to 10 kHz) having one of the richest variety of expected sources. The most promising technique for the direct detection of gravitational waves in this band is long baseline laser interferometry [1, 2]. A Michelson interferometer has an ideal geometry to compare the strains along the two axes perpendicular to the direction of travel of the wave, and offers the high sensitivity associated with an interferometric measurement. Moreover, one can make the arms long so as to increase the motion of the mirrors relative to one another and thus increase the sensitivity to h. Even so, for a sensitivity of value of $h = 10^{-22}$ the corresponding absolute change in arm length of a 4 km long detector caused by a gravitational wave will be only about 10^{-19} metres, or 1/10,000 the diameter of a proton!

With a typical laser wavelength of 1 μm, the required sensitivity corresponding to a change in arm-length of 10^{-19} m is less than 10^{-13} of the wavelength of the laser. Moreover, we must protect the mirrors from any spurious (non-gravitational wave) sources of motion at the level of less than 10^{-19} m. These sources range from seismic motion, to radiation pressure, shot noise, thermal noise in the mirrors and coatings and residual gas molecular bombardment of the mirrors and associated fluctuations in the refractive index. This is the challenge of gravitational wave detection, one which has been driving precision measurement science for more than three decades.

'In close collaboration with the international community, Australia could be a leading player in this most important emerging experimental field.'

During the past several decades, physicists worldwide have perfected these interferometers, with large experimental teams in the USA (LIGO) [3], Europe (VIRGO and GEO) and Japan (TAMA 300) and with contributions from many other scientists, including the Australian Consortium for Gravitational Wave Astronomy (ACIGA) in Australia [4]. The improvements have lead to substantial modifications to the simple interferometer shown in Fig. 2. The improvements include high finesse Fabry-Perot interferometers in each arm to increase the interaction time with the gravitational wave, power recycling mirrors on the laser to increase the stored

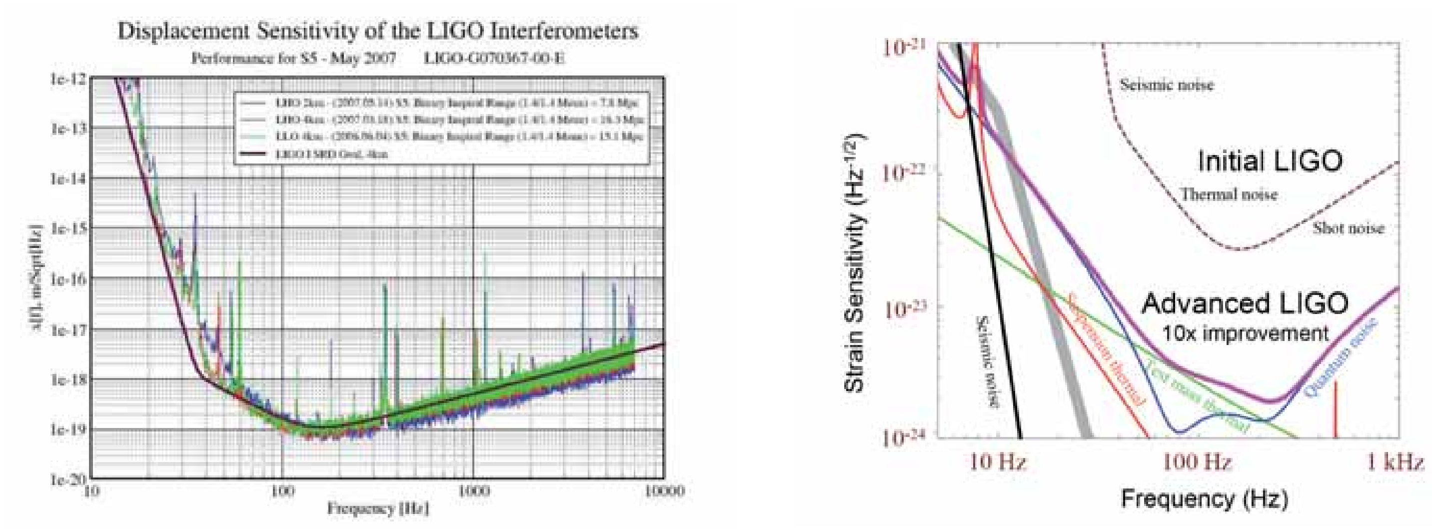


Fig. 3. The initial LIGO has been a great success, and has paved the way for an upgrade known as Advanced LIGO. Initial LIGO reached its design sensitivity of $h = \Delta L/L = 3 \times 10^{-23}/\sqrt{\text{Hz}}$, corresponding to an integrated sensitivity of $h = 10^{-22}$ over the effective bandwidth of the detector. The parameters influencing the sensitivity are fully understood, and the improvements in sensitivity of Advanced LIGO are directly traceable to known technology. The improvements required in each subsystem are indicated, resulting in the overall sensitivity of Advanced LIGO (solid pink line) compared to the achieved sensitivity of Initial LIGO (black dotted line)

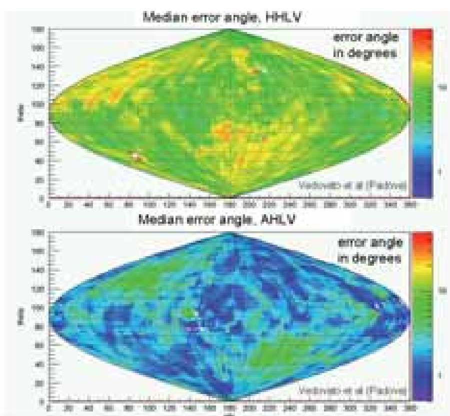


Fig. 4. LIGO-Australia will enable us to pinpoint gravitational wave sources in the sky for gravitational wave astronomy. The Northern Hemisphere network for source localisation without LIGO-Australia (upper map) can be dramatically improved by turning the existing planar array into a tetrahedral configuration with LIGO-Australia (lower map). Source uncertainty regions can be as small as one square-degree, with uncertainty contours that are roughly circular. Once LIGO-Australia is in place, the error ellipses are well matched to the field of x-ray, optical, and radio telescopes, similar to the Square Kilometre Array (SKA). This will revolutionise the speed and effectiveness with which electromagnetic telescopes can identify and study sources.

power to reduce shot noise and many other advances discussed below and elsewhere [5].

The culmination was LIGO's achievement in 2006 of its initial design sensitivity – see Fig. 3. This demonstrated that it is possible to measure such small changes and, that with additional improvements in all subsystems, a further increase in sensitivity by a factor of 10 is feasible. As a result of this success, Advanced LIGO in the US and advanced Virgo in Europe were approved for funding.

Why Australia?

The proposal to place a detector in Australia is an outcome of a 2009 study carried out by the Gravitational Wave International Committee (GWIC) to create a Roadmap for gravitational waves [6]. The Roadmap has strongly argued the need for the timely establishment of additional advanced detectors to complement the array of three large advanced, separated facilities then under development in the Northern Hemisphere – two by the LIGO Laboratory in the US and one by Virgo in Italy. This recommendation is a direct consequence of the method of locating sources and hence fundamental to gravitational wave astronomy.

A single gravitational wave detector can in principle detect a passing wave, but would yield essentially no information about the location of the source, in the same way a simple dipole antenna gives almost no information about the location of a source of electromagnetic waves. Triangulation from the difference in timing from separate detectors (equivalent to using an array of dipoles to synthesise a directional beam for radio astronomy) is required to determine the location of the source. With detectors at three widely separated sites, sources perpendicular to the plane they define can be well located, but for the (large) part of the sky near the plane, the angular uncertainty is too large to be useful. With a fourth detector located well out of the plane of the first three – in Australia – precision astronomy becomes a possibility, as shown in Fig. 4.

> **'… the existence of gravitational waves has already been confirmed to the satisfaction of the Nobel Foundation which awarded the 1993 Nobel Prize in Physics to Russell Hulse and Joseph Taylor…'**

The LIGO-Australia project

LIGO Laboratory is currently building *three* Advanced LIGO detectors, where the original plan was to install two of these in the same vacuum system at Hanford. How-

ever, as discussed above, the international scientific community would greatly benefit from locating one of the detectors in Australia. Thus, as a result of the strong recommendation by the international community, led by GWIC, and of a continuing close collaboration between the LIGO Laboratory in the USA and the Australian Consortium for Gravitational Wave Astronomy (ACIGA), the LIGO-Laboratory has, with the approval of its funding agency, the National Science Foundation (NSF), offered to locate in Australia one of the Advanced LIGO detectors currently being built. This would place an exact copy of the world's most advanced and sensitive detector in Australia to participate in the discovery and subsequent exploitation of gravitational waves

The offer is contingent on Australia providing the infrastructure to house the detector and the personnel required to assemble, install and operate it. A decision to accept the offer, including a firm commitment to the funding required, must be made by October 2011; otherwise, the detector in question will be installed in the Hanford LIGO Laboratory as originally planned, to maintain the tight Advanced-LIGO project schedule.

Under this agreement, the LIGO Laboratory would ship all the detector components to Australia, and they would be assembled and installed in purpose built facilities. The components to be shipped would include the superb core optics consisting of 40 kg, 35 cm diameter, ultra-pure, fused silica, polished to better than one thousandth of a wavelength (less than 1 nm), and coated by the CSIRO with ultra-low loss optical coatings to a precision of single atomic layers.

Other components will be monolithic fused silica suspension systems developed by GEO to protect the optics from ambient vibrations and disturbances at the 10^{-19} m level at frequencies above a few Hz; high power single frequency lasers from the Max Planck Institute; input and output optics from LIGO and the ANU; adaptive optics from LIGO and Adelaide; advanced computers for controlling the detector and for data storage and analyses; and many other components which are state-of-the-art individual sub-systems. A diagram of the Advanced LIGO detector is shown in Fig. 5.

While the LIGO offer will provide Australia with a state-of-the art advanced detector at essentially half the cost and at a much shorter time scale than that required to develop the detector independently, it is still a major undertaking. It will require building the largest ultra-high vacuum system in the Southern Hemisphere (10 megalitres) and providing all buildings, clean room facilities, control rooms and infrastructure required to run a major facility.

The photos in Fig. 6 of the LIGO Laboratory illustrate the magnitude of the task. Australia will benefit from access to the detailed drawings and design of the LIGO Laboratory, but more modern and regional variations in building standards will be used. Furthermore we have carried out extensive studies on making the laboratory energy efficient and with sustainable designs, including using solar power and the aquifers as a heat sink for stringent temperature control and air conditioning of the buildings.

A preliminary site selection and evaluation has also been completed. The plan is

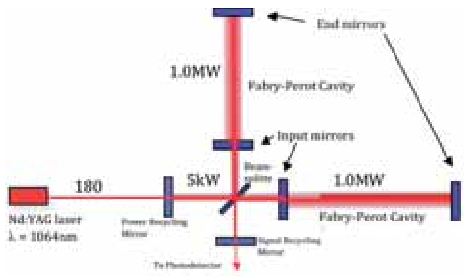


Fig. 5. To reach the sensitivity required, many improvements to the Michelson interferometer are required. Design features include the dual recycled configuration with Fabry-Perot arm cavities, power recycling, signal recycling mirrors and a high power laser. The best sensitivity occurs when the optical power on the photodetector is at minimum, and this allows power recycling of the laser to reach stored optical power levels of 1 MW. These improvements enable the sensitivity to reach $\Delta L/L = 10^{-22}$.

Fig. 6. Images from the LIGO Lab. A similar installation in Australia will be required to house and operate LIGO-Australia. Shown are the central buildings and one of the 4 km long arms; the central vacuum tanks required; the 1.2 m diameter beam tubes; and the portable clean rooms and control rooms buildings required (the beam tube in LIGO-Australia would be partially underground).

'The offer is contingent on Australia providing the infrastructure to house the detector and the personnel required to assemble, install and operate it.'

to place LIGO-Australia at a site near Gingin, WA, currently operated by the University of Western Australia and ACIGA as the home for the 80 m prototype. Management plans have also been completed, with the ACIGA universities collaborating to establish and operate LIGO-Australia with UWA as the host institution, and Dr Stan Whitcomb (chief scientist of the LIGO Laboratory) as the Director.

The future

In the next few months the scientific community in Australia will be called on to recommend whether we should accept this opportunity to bring a cutting edge experimental physics and astronomy facility to our shores. This decision seems easy based on the science, but difficult based on the costs, especially today. We have completed a careful costing exercise, based on the original costs of LIGO, normalised to Australian conditions in 2010, and meeting the review of LIGO Laboratory for completeness and accuracy

The whole project is expected to cost $A200 million over 15 years with $A140 million for construction and $A60 million in operational costs for ten years after construction is complete. We are also engaged in detailed discussions with scientists in India, who are very supportive and keen to participate and contribute significantly to the construction and operating budgets. Similar negotiations are under way with scientists in China.

Having a full-scale advanced detector in Australia would not only be an extremely significant scientific component of a world-wide array of detectors, but would also be the largest, the most complex and arguably the most significant single piece of experimental physics instrumentation on the continent, to serve as an inspiration and an educational tool for future generations of physicists and engineers.

Acknowledgments

This article has been written using material from LIGO, ACIGA and GWIC websites, with contributions from many authors in the international community. We are particularly grateful to Dr Jay Marx, Director of the LIGO-Laboratory, for initiating and supporting the LIGO-Australia concept.

References

[1] For more information see https://gwic.ligo.org/roadmap/.
[2] A good reference is P. R. Saulson, 'Fundamentals of Interferometric Gravitational Wave Detectors' (World Scientific, Singapore, 1994).
[3] See e.g. www.ligo.caltech.edu.
[4] ACIGA currently consists of the universities represented by the authors of this article and the associated research groups in gravitational wave detection. A total of about 50 Australian staff and students are currently involved – see www.anu.edu.au/physics/ACIGA.
[5] For the Advanced LIGO Ref Design see: www.ligo.caltech.edu.au/docs/M/M060056-08/M060056-08.
[6] The Gravitational Wave International Committee (GWIC) was formed in 1997 to facilitate international collaboration and cooperation in the construction, operation and use of the major gravitational wave detection facilities world-wide. It is affiliated with the International Union of Pure and Applied Physics as a sub-committee of its Particle and Nuclear Astrophysics and Gravitation International Committee. For more information see https://gwic.ligo.org/ roadmap.

Bio

Professor Jesper Munch holds the Chair of Experimental Physics at the University of Adelaide, and is the current chair of the Australian Consortium for Gravitational Wave Astronomy (ACIGA). His main interests are in coherent optics and lasers with major interests in frequency stabilisation, high power lasers, holography, phase conjugation, nonlinear optics and gravitational wave detection. Most recently his work has concentrated on equipment for Advanced LIGO, fibre lasers and a new approach to pulsed guide-star lasers for aberration correction in very large astronomical telescopes. He has a BSc in physics from the Massachusetts Institute of Technology (1968) and a PhD in physics from the University of Chicago (1975). Jesper is the corresponding author and can be contacted at jesper.munch@adelaide.edu.au.

Letter

Dear Editor,

A Problem with Entanglement regarding Special Relativity

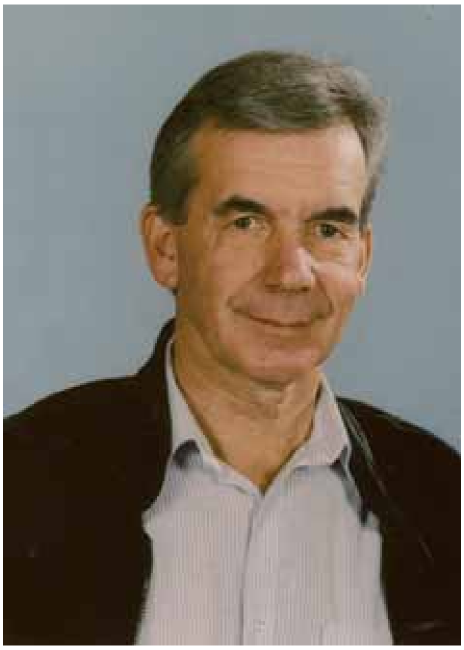
According to many popular descriptions of Entanglement, when the local member of the mixed-state pair is 'observed' (measured), its quantum state collapses to an eigenstate of the local measuring apparatus, and *simultaneously*, the quantum state of the remote member collapses to its corresponding state, no matter what the spatial separation happens to be.

Special Relativity has a big problem with this description since according to SR, there is only one inertial frame of reference in which two spatially separated events can be simultaneous. In all other frames of reference, the two events are not simultaneous and indeed the time ordering of the two events depends upon the frame from which they are viewed [1]. So, right away, we have a violation of the Principle of Relativity since the *physics* of the situation depends upon the frame in which the events are viewed. That is, there is only *one* frame in which the Entanglement assertion can hold. In all other frames, the assertion cannot hold.

I believe we can resolve this problem with a simple paradigm shift [2]. The traditional view seems to be that the collapse of state A causes the collapse of the remote state B, instantaneously, faster than the speed of light. I would like to suggest that it is not some mystical agency which has travelled vast distances faster than light [3], but rather it is simply my *knowledge* of the distant state which is resolved instantaneously. In other words, it is not some mysterious quantum wave which has travelled from London to Los Angeles, but rather the knowledge has travelled from one synapse in my brain to another at much less than the speed of light.

These thoughts bring to light another small problem regarding

Obituary



Stuart Tovey (1939 – 2010)

Geoffrey Taylor
University of Melbourne

Stuart Tovey, who did much to bring about Australian participation in CERN, died in Melbourne on 21 October 2010 after a short illness.

Born in Southampton in 1939, Stuart grew up in Bristol. He studied physics at Trinity College, Cambridge, and received his BA in 1960. Returning to Bristol he joined Cecil Powell's cosmic-ray group and gained his PhD there in 1964. A series of fellowships followed at Bristol, University College London, CERN and the Rutherford Appleton Laboratory. He joined the University of Melbourne as a lecturer in 1975, being rapidly promoted to senior lecturer and then to reader and associate professor

Stuart was prominent in the 1960s and 1970s in the study of hyperons and kaons and discovered a new baryon containing both charm and strange quarks. He put the many interestingly named particles to good use in the numerous popular articles he wrote. He also studied antiprotons and participated in the discovery of the W and Z bosons at CERN in the UA2 experiment. This experience further evolved into development of the ATLAS experiment at the LHC.

For many years Stuart coordinated the honours physics programme at Melbourne, which was not for the faint-hearted. He showed how adept and in-tune with people he was in this role, treading the fine line between encouragement and realism, in the latter case counselling students towards alternative directions when he thought that it be in their best interest. The honours students of the period were very well served and many went on to PhD studies, often under Stuart's guidance.

Stuart's international engagement and solid personal and professional ties with CERN ensured strong participation in ATLAS by Australia. While ATLAS and the Large Hadron Collider (LHC) were being built, Stuart and his friend and colleague, Lawrence Peak from Sydney, shared a role as the fathers of modern high-energy physics in Australia. The Australian Institute for High Energy Physics was formed, for which Stuart was the chair for many years. Australia also joined the NOMAD experiment at CERN, followed by the Belle experiment in Japan.

Fortunately, Stuart was able to share in the excitement of the successful operation of the LHC and ATLAS. Although formally retired in 2001, he maintained an active interest in the project, being Australia's representative on the ATLAS Resource Review Board until very recently. He also witnessed the successful establishment of a national Centre of Excellence in Particle Physics (CoEPP) in Australia, something he strove for over many years. After writing a paper on collider physics together in 1984, Stuart and Allan Clark of the University of Geneva pursued a role for Australia's participation in ATLAS. They were ahead of their time: the CoEPP gives justification to their early recognition of the need for such participation.

Stuart's untimely death is acutely felt by colleagues and friends at the University of Melbourne, and by those at the many institutions around the world who have worked with him. He will be missed.

the actual measurement process. When the local member is 'observed' (measured), it is presented to some measurement apparatus and the quantum state emerging from the apparatus will necessarily be one of the eigenstates of the apparatus ('Lectures on Physics', Feynman, vol. 3). Most measurements are actually destructive in that they change the quantum state in some way. Indeed, the only time the measurement is non-destructive is if the initial quantum state just happens to be an eigenstate of the measurement apparatus. Unfortunately, the amount of this change is generally one of those quantum 'unknowables' that Einstein did not like. A good example of this is Heisenberg's gamma-ray microscope. The measurement disturbs the system in an unknowable way.

That being the case, when a destructive measurement is performed on the local member, we no longer have a two-body system. Now, the conserved quantity is shared among three bodies, the two original ones plus an unknown and unknowable amount to the measurement apparatus. And unfortunately, this destroys any knowledge I might have had concerning the remote member. At this point, I would not be able to predict the outcome of a measurement on the remote member.

[1] This time ordering of events is what limits causally connected events to less than or equal to speed of light interactions.

[2] The ancient Egyptians believed that sight was something which emanated from the eye to probe the external world. They knew that the stars were very far away and using their paradigm, they could prove that the speed of sight was infinite since they could immediately see the stars when they opened their eyes.

[3] At the 1928 Solvay Congress, Einstein referred to a 'spooky action at a distance'.

Sincerely,

Jack Higbie
Danville, California

Product News

Lastek

Lowest Profile 3-axis Nanopositioners from Mad City Lab

The Nano-LPQ is the lowest profile high speed XYZ nanopositioner available and offers 75 x 75 x 50μm travel with picometer position noise under closed loop control. The Nano-LPQ features equal millisecond

response times in XYZ, an integrated sample holder, analog and digital control with added scan synchronization features, and compatibility with major image and automation software.

Designed to minimize the moving mass, lightweight sample holders are integrated into the stage and represent the only moving component. This unusual design allows the three axes of motion to have matched resonant frequencies and step response times. Equal 3-axis speed is particularly useful for applications like 3D particle tracking. The Nano-LPQ uses internal position sensors utilizing proprietary PicoQ™ technology to provide absolute, repeatable position measurement with sub-nanometer resolution under closed loop control.

The Nano-LPQ is LabView™ and C++ compatible and is supplied with Mad City Labs' Nano-Route™3D software, for ease of use.

Features:
- Low profile, high speed, XYZ motion
- Built-in sample holders
- Equal speeds on all three axes
- Closed loop control

Typical Applications:
- Optical microscopy, easy to retrofit
- Optical trapping experiments
- Fluorescence imaging
- Particle tracking
- Single molecule spectroscopy

The Nano-LPS Series is the lowest profile 3 axis piezo nanopositioning systems suitable for applications such as super resolution (SR) microscopy and force microscopy. The Nano-LPS series continues the innovative design approach originally introduced by Mad City Labs. At only 20mm tall and an 83mm wide center aperture, the Nano-LPS series is designed for practical microscopy users interested in nanoscale phenomena. The Nano-LPS series features up to 300 microns of motion per axis and picometer precision under closed loop control. The low height of the Nano-LPS Series allows it to be easily integrated into existing inverted optical microscopes. Like the related Nano-LP Series, the Nano-LPS Series is ideal for demanding microscopy applications which require long range travel, fast scan rates, and three axes of motion.

Mad City Labs proprietary PicoQ™ sensors enable picometer position noise with ultra high stability, which is important for demanding applications such as SR microscopy techniques.

Features:
- Lowest profile 3-axis nanopositioner available
- Large aperture for standard 3" slides
- 100 μm, 200 μm, and 300 μm ranges of motion (XYZ). Closed loop control

Typical Applications:
- Optical microscopy, easy to retrofit
- Optical trapping experiments
- Fluorescence imaging
- Alignment
- Single molecule spectroscopy

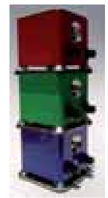
Ocean Optics acquires Sandhouse Design

Ocean Optics extended its product family after acquiring Sandhouse Design, LLC.

Sandhouse developed a unique line of high-powered LED light sources for research and spectroscopic applications.

These products have been widely used in biotechnology, process control and industrial applications.

LED Light Sources



These ergonomic and smartly designed fiber-coupled LED light sources are ideal for fluorescence, spectroscopy and general fiber illumination applications. The Ultra LED high-power light sources can be operated in continuous or external trigger modes. Available in UV, VIS and Infrared.

SIR Scanning Spectrometers

The SIR Scanning Spectrometer Series from Ocean Optics provides you a range of fiber-based spectral data collection in a detection instrument that is built to last and always reliable.

These SIR Scanning Spectrometers feature USB 2.0-compliant interfaces that provide fast data transfers. Plus, the included software can be used to control all of your SIR spectrometer's functions as well as analyse data.

The SIR spectrometer family includes:
- SIR-1700: 400-1700 nm
- SIR-2600: 0.9-2.6 μm
- SIR-3400: 1-3.4 μm
- SIR-5000: 2-5 μm
- SIR-6500: 3.0-6.5 μm

Deep UV LEDs

Sandhouse Deep UV LEDs are available in a wide range of wavelengths and package sizes. These devices are manufactured using AlGaN/GaN technology, which enables a new generation of high band-gap energy opto-electronics devices, able to perform down to 240 nm.

Latest News from Toptica Photonics

Multi-Colour Systems – Multi-Laser Engines and Tunable VISible Lasers

Three exciting new systems are now available from Toptica:

iChrome MLE-L

Multi Laser Engine with up to three diode lasers and one DPSS Laser fully integrated in one compact box.

- Multi-line laser with up to four laser lines
- Wavelengths diode lasers: 405, 445, 488 and 640 nm (375, 473, 660, 785 nm and others on request)
- Wavelengths DPSS laser: 532 and 561 nm (505, 515, 594 nm and others on request)

iChrome MLE-S

All-diode Multi Laser Engine with up to four diode lasers fully integrated in one compact box.

- Multi Line Laser with up to four diode laser lines
- Available wavelengths: 405, 445, 488 and 640 nm (375, 473, 660, 785 nm and others on request)
- High free-space and fibre coupled output power levels

Common to both MLE models

The individual lasers are efficiently combined and delivered free beam or via an all-in-one PM/ SM fibre output. The microprocessor controlled system enables flexible OEM integration. High speed analogue and digital modulations allow fast switching of laser wavelength and intensity.

TOPTICA's ingenious COOL^{AC} technology automatically aligns the system with a single push of a button. This feature ensures a constant optical output level even under strongly varying ambient conditions and completely eliminates the need for manual realignment - making the iChrome MLE the most advanced multi-line laser system on the market.

- Single mode, polarisation maintaining fibre output or free beam COOLAC technology for highest coupling efficiency, ultimate stability and drop-shipment capability
- Direct modulation and fast switching between wavelengths
- True one-box solution with integrated electronics
- Unique features: COOLAC, FINE and SKILL technology
- Most compact and cost effective solution for multicolour biophotonic applications

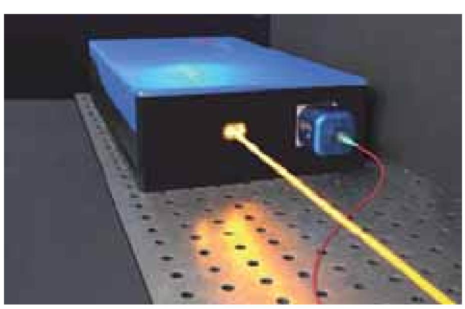
iChrome TVIS

Our ultrachrome picosecond laser is:

- Continuously tunable in the visible range of 488 – 640 nm
- Fibre coupled output (single-mode)
- Fully automated operation
- Pure colour, narrow emission bandwidth (< 3 nm)
- Perfectly suited for fluorescence lifetime imaging microscopy (FLIM) or optical testing of components

The iChrome TVIS laser system is a fibre laser with the flexibility to set automatically the laser output to any wavelength in the visible (488 – 640 nm). The coherent laser output ensures that the visible light exhibits the best intensity noise performance and the use of polarisation maintaining optical components a stable linear polarisation of the fibre coupled output beam is achieved. The entire laser system is extremely user friendly: No alignment procedures of any optical components distract the user from the main task – to produce results.

DL-RFA-SHG pro @ 589nm 2 Watt, single line for sodium cooling



The new DL RFA SHG pro is a narrow-band tunable continuous wave laser for sodium cooling. The system is based on a near-IR diode laser in the successful 'pro-design' (DL 100/pro design, 1178 nm), with a subsequent Raman fibre amplifier (RFA) and a resonant frequency doubling stage (SHG pro).

The DL RFA SHG pro features a spectral linewidth below 1 MHz and 20 GHz mode-hop free tuning. For system operation, no water cooling and no external pump is required. The power scalable approach of the DL RFA SHG pro also offers solutions for other high power applications such as sodium LIDAR, medical therapy or super resolution microscopy. Customised systems with higher output powers up to 10 W are available on request. Wavelengths between 560 and 620 nm will soon be available as customised solutions.

FemtoFiber pro – the product family is expanded

After the successful introduction of the FemtoFiber pro IR, NIR and SCIR models, TOPTICA is now taking the final step to also include the remaining system variants such as tunable visible (TVIS), tunable near-infrared (TNIR) and tunable ultra compressed pulse (UCP). Options such as variable repetition rate (VAR) and a phase-locked loop Laser Repetition rate Control (LRC) by TOPTICA's well-established PLL-electronics are rounding up the FemtoFiber pro product family.

The first and fastest of the new models, UCP, shows short pulses in the range down to 13 fs, the fastest available on the market from a turnkey SAM modelocked fibre laser system.

The TVIS expands the super-continuum generation (SCIR) by a tunable second harmonic generation and allows transferring femtosecond pulse generation into the visible wavelength range from 490 to 700 nm.

The TNIR variant finally adds a new feature to the FemtoFiber pro family. As opposed to the TVIS, it uses the high-band continuum (>1560 nm) for second harmonic generation. This continuum part is a solitonic pulse and therefore needs no pulse compression. The output wavelength can be tuned from 800 to 1100 nm. This variant was not previously available in the FFS product family.

For more information please contact Lastek at sales@lastek.com.au
Lastek Pty Ld
Adelaide University - Thebarton Campus
10 Reid St, Thebarton, SA
Aus 1800 882 215; NZ 0800 441 005
T: (61 8) 8443 8668; F: (61 8) 8443 8427
email: sales@lastek.com.au
web: www.lastek.com.au

Warsash

Lightweight Benchtop Vibration Isolation

Warsash Scientific is pleased to announce a new lightweight benchtop vibration isolation system from Kinetic Systems, Inc. Specifically designed for portability, the ELpF can be easily repositioned on the benchtop, even with a load and in float. Its unique, self-contained design provides this without causing damage to the vibration isolators.

An economical alternative to heavyweight models, the Ergonomic Low-Profile-Format platform provides vibration isolation for sensitive devices. It features a load capacity of 100 or 300 lbs. in a lightweight, ergonomic system.

The platform has a low profile (only 3" high), uses a small tabletop (16" x 19" standard), and weighs 40 lbs., making it very portable. Ergonomic features include gauges tilted upward for easier viewing and recessed handles for easy carrying.

Designed for use in laboratories and Class 100 cleanrooms, the ELpF platform is ideal for supporting atomic force microscopes, microhardness testers, analytical balances, profilometers, and audio equipment.

Self-leveling and active-air isolation give the platform low natural frequencies (1.75 Hz vertical, 2.0 Hz horizontal) and typical isolation efficiencies of 95% (vertical) and 92% (horizontal) at 10 Hz.

Other tabletop sizes can be customized per specifications. The top, which can be ordered with or without mounting holes, can be aluminum plate, ferromagnetic stainless steel, plastic laminate, or anti-static laminate.

For more details on this or other vibration isolation equipment, contact
sales@warsash.com.au

Real-Time Operating System for Systems Integration

PI (Physik Instrumente), the leading manufacturer of piezoceramic drives and positioning systems, offers a real-time module as an upgrade option for the host PC and also the connection of the GCS (PI General Command Set) software drivers. The module is based on Knoppix-Linux in conjunction with a pre-configured Linux real-time extension (RTAI).

The use of real-time operating systems on the host PC allows it to communicate with other system components, e.g. a vision system, without time delays with discrete temporal behavior and high system clock rate.

A library which is 100% compatible with all other PI GCS libraries is used for the communication with the real-time system. All PI GCS host software available for Linux can be run on this system.

The real-time system running in the real-time kernel can be used to integrate PI interfaces and additional data acquisition boards for control. Open functions to enable you to implement your own control algorithms are provided. Data, such as positions and voltages, is recorded in real time, and pre-defined tables, with positions, for example, are output in real time to the PI interface and to additional data acquisition boards.

You can program your own real-time functions in C/C++, MATLAB/ SIMULINK and SCILAB.

The system includes a PI GCS server, which allows the system to be operated as a blackbox using TCP/IP, via a Windows computer, for example.

The system can be installed on a PC or booted directly as a live version from the data carrier. A free demo version with restricted functionality is available.

For more information on the real time operating software or other PI positioning equipment, contact sales@warsash.com.au

E-618: 3.2 kW Peak Power for New Piezo Amplifier

Available from Warsash Scientific is the new PI (Physik Instrumente) E-618 high power amplifier for ultra-high dynamics operation of PICMA® piezo actuators.

The amplifier can output and sink a peak current of 20A in the voltage range between -30 and +130V. The high bandwidth of over 15kHz makes it possible to exploit the dynamics of the PICMA® actuators. This type of performance is required in active vibration cancellation and fast valve actuation applications.

The E-618 also comes with a temperature sensor input to shut down the amplifier if the maximum allowed temperature of the piezo ceramics has been exceeded. This is a valuable safety feature given the extremely high power output.

The E-618 is available in several open-loop and closed-loop versions with analogue and digital interfaces.

For more information on these and the range of other PI products, contact
sales@warsash.com.au
Warsash Scientific Pty Ltd
Tel: +61 2 9319 0122
Fax: +61 2 9318 2192
www.warsash.com.au

New Sensors Improve Precision of S-340 Tip/Tilt Mirror

Warsash Scientific is pleased to announce the release of the new S-340 piezo tip/tilt mirror platform from PI (Physik Instrumente), equipped with new high-resolution strain gauge sensors.

The S-340 now achieves a resolution of 20nrad at angles of 2mrad about both orthogonal axes.

This large mirror platform is used for optics with diameters of up to 100 mm (4 inches) and achieves a resonant frequency of 900Hz for a mirror of 50 mm diameter.

The S-340 can be operated by the new, low-cost E-616 controller. Together, they form a compact, high-performance solution for beam control and image stabilization as employed in astronomy, laser machining or optical metrology, for example.

For more information on the S-340 Tip/Tilt Mirror platform or other Positioning equipment from PI, contact sales@warsash.com.au

Coherent

Princeton Instruments

PI-MAX3 Intensified CCD Cameras

Princeton Instruments' PI-MAX series of intensified CCD cameras has set the standard for time-resolved imaging and spectroscopy for almost a decade. Now Princeton's PI-MAX3 takes ICCD performance to a new level with order of magnitude speed improvements and a host of new features to allow easier and more accurate time-resolved imaging.

PI-MAX3 is available in formats of 1024 x 1024 pixels for imaging and 1024 x 256 pixels for spectroscopy. Video frame rates can be achieved in the imaging format and spectral rates of thousands of spectra per second can be achieved. Most importantly, the camera allows sustained gating rates up to 1 MHz, a 20-fold improvement over previous designs.

The camera includes the improved SuperSynchro timing generator, SyncMaster clock output, a compact 'one-box' design, convenient GigE interface and much, much more.

For further information please contact Paul Wardill on
sales@coherent.com.au:
Coherent Scientific
116 Sir Donald Bradman Drive, Hilton SA 5033
ph: (08) 8150 5200 ; fax: (08) 8352 2020
www.coherent.com.au

Princeton Instruments

Light-Field 64-bit Acquisition Software

From the world leaders in optical spectroscopy and CCD/EMCCD/ICCD technology comes LightFieldTM, an all-new 64-bit data acquisition platform for spectroscopy and imaging. LightFieldTM combines complete control over Princeton Instruments' cameras and spectrometers with easy-to-use tools for experimental setup, data acquisition and post-processing.

LightfieldTM ensures data integrity via automatic saving to disc, time stamping and retention of both raw and corrected data with full experimental details saved in each file. LightFieldTM works seamlessly in multi-user facilities, remembering each user's hardware and software configurations and tailoring options and features accordingly. The optional, patent-pending IntelliCal package is the highest-performance wavelength calibration software available, providing up to ten times greater accuracy across the entire focal plane than competing routines.

Features include:

- Immediate data acquisition upon launch
- Progressive disclosure - contextual menus ensure that only relevant options appear
- Graphical hardware configuration builder ensures that system elements work exactly as the end user expects
- Dark gray GUI reduces monitor brightness; monitor dims automatically during acquisition
- All experimental parameters are saved to data file headers - no more searching old notebooks for data acquisition settings
- Automatic light saturation warning with pseudocolour
- Multiple regions of interest can be defined in a single window
- Save and reload experimental settings and share between multiple users
- Configurable setting dock holds preferred commands
- Control multiple cameras via multiple instances of LightField
- Drag-n-drop data into Excel, Paint and Notebook or export to TIFF, FITS, CSV etc.
- Peak find function works with both narrow and broad lines
- IntelliCal provides up to ten times improved accuracy

For further information please contact Paul Wardill on sales@coherent.com.au:
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116 Sir Donald Bradman Drive, Hilton SA 5033
ph: (08) 8150 5200 ; fax: (08) 8352 2020
www.coherent.com.au

Princeton Instruments

eXcelon…CCD and EMCCD sensitivity redefined

Princeton Instruments and Photometrics are pleased to announce the launch of new eXcelon back-illiminated charge-coupled device (CCD) and electron-multiplication CCD (EMCCD) detector technology that will revolutionise scientific imaging and spectroscopy.

New eXelon sensors provide excellent photon-detection capabilities across a wide spectrum, from 200 to 1100nm, and are particularly beneficial for applications requiring enhanced sensitivity in the blue and near-infrared (NIR) region, as illustrated below. In addition, eXcelon back-illuminated sensors significantly reduce etaloning (the problematic appearance of fringes).

When eXelcon technology is applied to EMCCD devices, the result is a detector with sub-electron read noise, superb sensitivity, low dark current, little (if any)

etaloning and high frame rates.

New eXcelon technology will be featured in Princeton Instruments' PIXIS and ProEM deep-cooled cameras and is available in several pixel-array formats:

- 1340 x 100 and 1340 x 400 CCD cameras for spectroscopy
- 512 x 512 and 2048 x 2048 for imaging

The technology is also available in 512 x 512 and 1024 x 1024 ProEM EMCCD cameras.

These new eXcelon-enabled cameras will target a wide variety of applications in both the life and physical sciences. Examples include astronomy, Raman spectroscopy, live-cell imaging confocal imaging, total internal reflection fluorescence microscopy (TIRFM), Forster resonance energy transfer (FRET), Bose-Einstein condensate (BEC) imaging, solar cell inspection, as well as super resolution techniques such as STORM and PALM.

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Physics Decadal Plan

The Australian Academy of Science is overseeing the development of a new Decadal Plan for Physics. The AIP has been charged with the responsibility of running the process of developing the plan. A similar process was last run in 1993 which produced the publication 'Physics: A Vision for the Future'. The Australian Research Council has granted funds to support the development of the new plan.

Michelle Simmons (UNSW), in her role as the Chair of the Academy of Science National Committee for Physics, has appointed David Jamieson (UMelbourne and past AIP president) to convene a Working Group to take the process to the next stage. The Working Group includes Hans Bachor (ANU), Cathy Foley (CSIRO), Ian McArthur (UWA), John O'Connor (UNewcastle), Halina Rubinsztein-Dunlop (UQueensland), Brian James (USydney and past AIP president).

The Working Group has been busy interviewing a large number of physicists in academia, CSIRO, DSTO, ANSTO, schools, industry, government, representative organisations and many other segments of the physics community. There was also a second interview process to establish the research resource requirements of the various physics sub-disciplines and their views on what the big opportunities for research are for the next 10 years. From these interviews the common issues affecting all will be identified and specific requirements for solutions will be developed.

The Decadal Plan consists of two broad components. The first is an inward looking component which will consist of a survey of Physics in Australia today to show how the discipline has evolved since 1993 and identify the significant areas of activity and expertise. The second is a forward looking component that aims to identify emerging opportunities that can be highlighted and developed. The Plan aims to have a broad audience and will serve to make the excitement and potential of Physics in the twenty-first century accessible to a wide audience.

Both components have called for comment and vision from the Physics community through a website, town hall meetings and the call for white papers. The deadline for submission of white papers was the beginning of April 2011. Most important has been the opportunity for delegates to the 2010 AIP Congress last December to present their views at dedicated sessions that were held during the Congress week.

A further six months of consultation and review will follow before the draft plan, provisionally titled 'Investing in the future of Physics' which will be presented to the Academy in July 2011.

Further information is available at www.physicsdecadalplan.org.au/home.

Conferences

29 May – 3 June 2011
Fourth International Conference on Chaotic Modelling, Simulation and Applications
Agios Nikolaos, Greece

28 June – 1 July 2011
Twenty-fifth International Union of Geodesy and Geophysics (IUGG) General Assembly: Earth on the Edge
Melbourne Convention & Exhibition Centre

1 – 3 July 2011
Astronomical Society of Australia's Harley Wood Winter School
Adare House, Victor Harbor, SA

4 – 8 July 2011
Astronomical Society of Australia's Annual Science Meeting
University of Adelaide, SA

4 – 8 July 2011
Fifteenth International Conference for Women Engineers and Scientists (ICWES15)
Adelaide Convention Centre, SA

19 – 22 July 2011
American Association of Physics Teachers (AAPT) 2011 Summer Meeting
Omaha, Nebraska

30 July – 3 August 2011
Twenty-second General Assembly and Congress of the International Union of Crystallography (IUCr)
Madrid

22 – 31 August 2011
URSI General Assembly and Scientific Symposium of International Union of Radio Science
Istanbul, Turkey

13 – 20 August 2011
IQEC/CLEO Pacific Rim 2011
Sydney

28 August – 1 September 2011
International Conference on Nanoscience & Technology, ChinaNANO 2011
Beijing

7 – 9 September 2011
Thirty-sixth Annual Condensed Matter & Materials Meeting
Charles Sturt University, Wagga Wagga

31 January – 3 February 2012
Queensland Astronomy Education Conference (QAEC)
Brisbane

25 February 2012
Thirty-sixth International Conference on High Energy Physics, ICHEP2012
Melbourne Convention and Exhibition Centre

4 – 11 July 2012
Nuclei in the Cosmos 2012
Cairns Convention Centre, Qld

5 – 10 August 2012
Fifteenth International Conference on Small-angle Scattering, SAS 2012
Sydney